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THE NET IMPACT OF 'OTHER VARIABLES'  
ON NEGOTIATED PROFIT FOR  
DEPARTMENT OF DEFENSE CONTRACTS

THESIS

Gerard R. Cavallo  
AFIT/GSM/LSP/90S-4

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FOR DEPARTMENT OF DEFENSE CONTRACTS

THESIS

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Systems Management

Gerard R. Cavallo, B.S.

Captain, USAF

September 1990

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## Preface

The purpose of this study was to determine if profits negotiated on DOD contracts were a direct result of the Weighted Guideline Profit Analysis Method. The analysis demonstrates that they are not. A model of the defense profit process was presented to show "Other Variables" which might be the cause of the disparity. In order to conduct the analysis, the profit "Z" score was developed to compare negotiated profits to their profit policy expected values. It is proposed that the profit "Z" score replace the mark-up rate as a measure of negotiated profit.

In performing the analysis and writing this thesis I have had a great deal of help from others. Above all I wish to express my appreciation to the unsung heroes who make the defense acquisition system work; a few of whom are noted in the bibliography. I also wish to thank Capt Mark Bergeron and Dr. Rita Wells for their encouragement and advice, and Dr Dan Reynolds for his assistance in developing the MATHCAD programs. Finally, I wish to thank my family, Diane, Mark, and Andrew for their understanding and cooperation.

Gerard R. Cavallo

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## Abstract

The objective of this thesis was to determine if profits negotiated on DOD contracts were a direct result of the Weighted Guidelines Profit Analysis Method, or if "Other Variables" had a net impact. The thesis proposes a model for the Defense Profit Process consisting of six steps from Policy Formulation to The Effect of Defense Profit Policy on the Defense Industrial Base. The thesis then focuses on the portion of the model which describes the step from weighted guidelines to negotiated profit. Two paths are proposed between weighted guidelines and negotiated profit: the "Actual Process" and the "Theoretical Process". The "Actual Process" includes the "Other Variables", the "Theoretical Process" does not. The results of both processes are measured using the profit "Z" score. The profit "Z" score is the number of standard deviations that separate the negotiated profit from the mean of the distribution of all possible profits.

The "Theoretical Process" assumes that weighted guidelines profit factor values are applied to negotiated costs. Based on the DFAR definition of normal profit factor values, the average of all individual contract profit "Z" scores should equal zero.

The "Actual Process" is represented by actual FY 89 negotiated profits and is assumed to include all factors including weighted guidelines which impact negotiated profits. The "Actual Process" is measured using the average of all "Z" scores calculated from individual contracts negotiated during FY 89.

*Weighted Guidelines Profit Analysis Method*  
*Defense Profit Process*  
*Other Variables*

The analysis concludes that the average 'Z' score for the 'Theoretical Process' does not equal the average 'Z' score for the 'Actual Process', therefore the 'Other Variables' do have a net impact on negotiated profits. It is proposed that the profit 'Z' score measurement replace the mark-up rate as a measure of negotiated profit. The profit 'Z' score provides a better measure of compliance with profit policy and has the additional benefit of being useful for individual feedback and process control.

THE NET IMPACT OF 'OTHER VARIABLES' ON NEGOTIATED PROFIT FOR  
DEPARTMENT OF DEFENSE CONTRACTS

I. Introduction

General Issue

The goals of Defense Profit Policy are to stimulate efficient contract performance, to induce capital investment, and to attract suppliers to the defense industrial base (1:215.902). Defense Profit Policy is based on the generally accepted principle that in a free market profit motivates performance, capital investment, and new suppliers. While it is generally accepted that profit motivates performance, capital investment, and new suppliers, the degree to which Defense Profit Policy can influence the achievement of these goals remains an issue.

A model of this Defense Profit Process issue is included as Figure 1. The model proposes that five steps exist between Defense Profit Policy and the Strength of the Defense Industrial Base. Associated with each of the five steps are variables, and a mechanism assumed to control the transition to the next step. Whenever terms referring to this model are used through out the remainder of the thesis they will be enclosed in quotations. A full discussion of the model is found in Chapter II.

The issue of the degree to which 'Defense Profit Policy' affects the 'Strength of the Defense Industrial Base' results from the location of

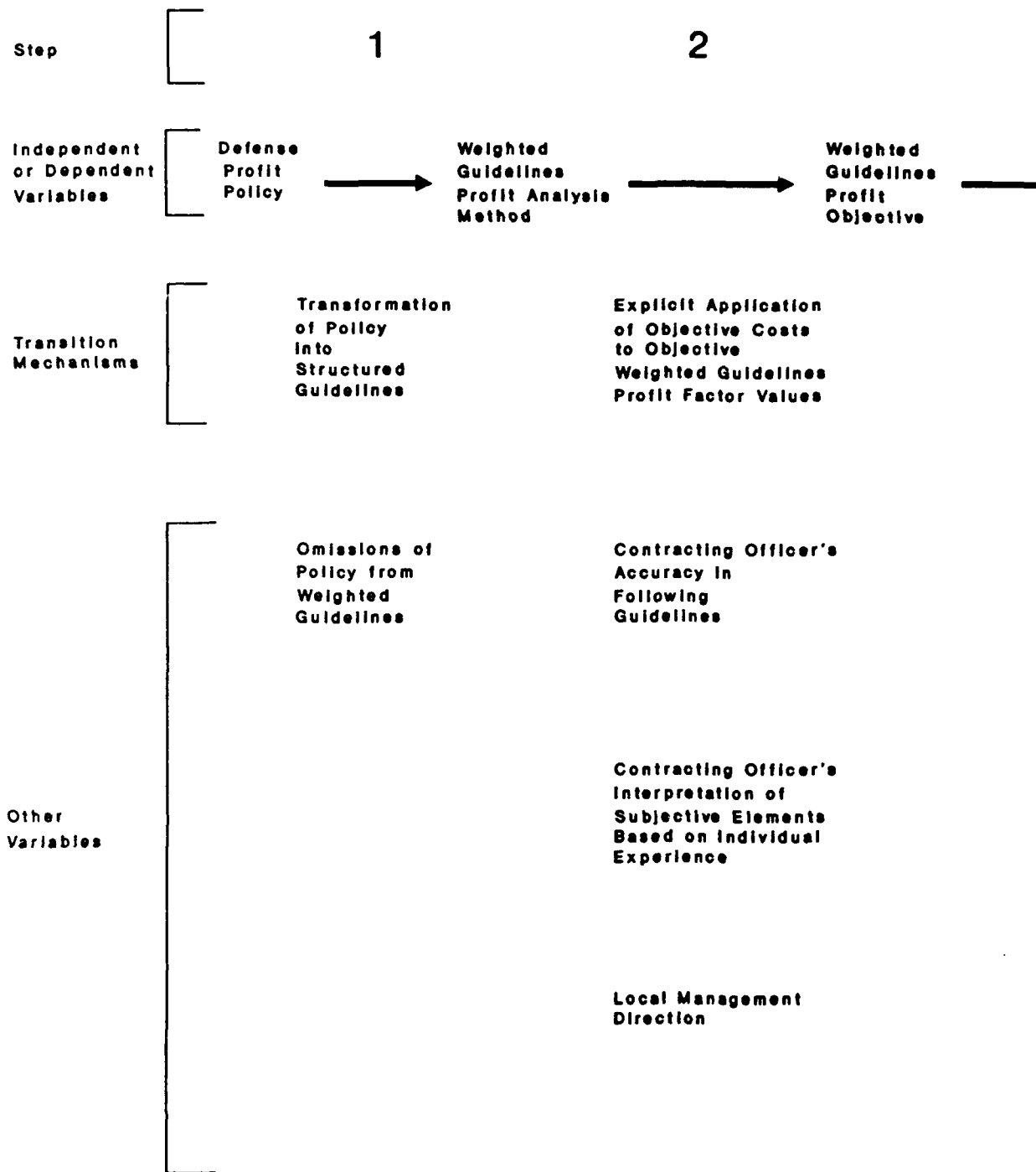


Figure 1. The Defense Profit Process Steps 1 through 5

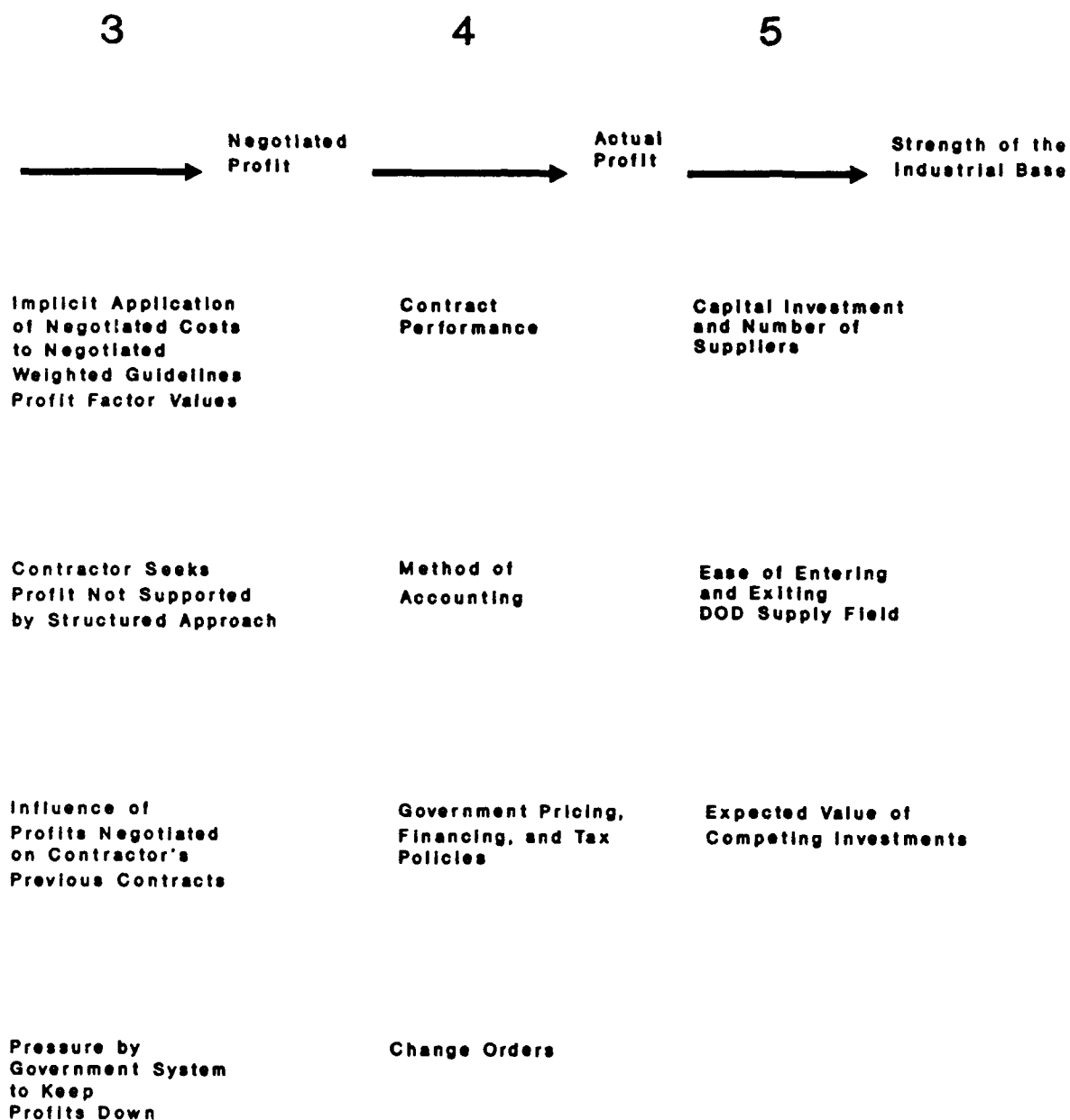


Figure 1. The Defense Profit Process Steps 1 through 5 continued



these variables in the model. "Defense Profit Policy" is several steps removed from "Negotiated Profit", the variable which is proposed to stimulate efficient contract performance, and "Actual Profit", the variable which is proposed to induce capital investment and attract suppliers to the defense industrial base. In order for "Defense Profit Policy" to control the "Strength of the Defense Industrial Base", the important variables which lie between "Defense Profit Policy" and the "Defense Industrial Base" must be controlled.

The important variables are those that significantly affect the dependent variable in each step. An important variable may be either an independent variable or a moderating variable. An independent variable is defined as having a strong causal relationship with a dependent variable and a moderating variable is defined as having a weaker but still significant causal relationship with the dependent variable.

The unimportant variables, also known as extraneous variables are those that do not significantly affect the dependent variable in each step.

This thesis assumes that "Defense Profit Policy" controls the independent variables through the use of the transition mechanisms shown in the Defense Profit Process model. Given this assumption, the question remains of whether the "Other Variables" are classified as moderating or extraneous. If they are moderating, then "Defense Profit Policy" must control their influence in order to maintain control over the defense profit process. If they are extraneous then they can be safely ignored.

### General Problem Statement

The general problem is whether or not the 'Other Variables' listed in Figure 1 are moderating variables in which case they must be controlled, or extraneous variables, in which case they can be safely ignored.

### Specific Issue

The general issue addressed the significance of the 'Other Variables' on the entire model and was illustrated in Figure 1. The specific issue narrows the focus of the thesis down to Defense Profit Process model 'Step 2' and 'Step 3'. The specific issue is illustrated in Figure 2. This is the part of the model which directly involves Defense Department employees and therefore the Department of Defense could most readily control if the 'Other Variables' were found to be moderating variables. Defense Profit Process model 'Steps 4 and 5' are not a part of the specific issue. These steps do not directly involve Defense Department employees and therefore the Department of Defense would have difficulty controlling the 'Other Variables' even if they were found to be moderating variables. Another reason 'Steps 4 and 5' were excluded from the research was that the measurements of the dependent variables 'Actual Profit' and 'Strength of the Defense Industrial Base' are not readily available although the General Accounting Office has proposed a program to measure 'Actual Profit'(8:2). 'Step 1' is also not part of the specific issue. It was felt that the independent variable 'Defense Profit Policy' was difficult to measure and that its transformation into the 'Weighted Guidelines Profit Analysis Method' was accomplished in sufficient detail for the purpose of this research.

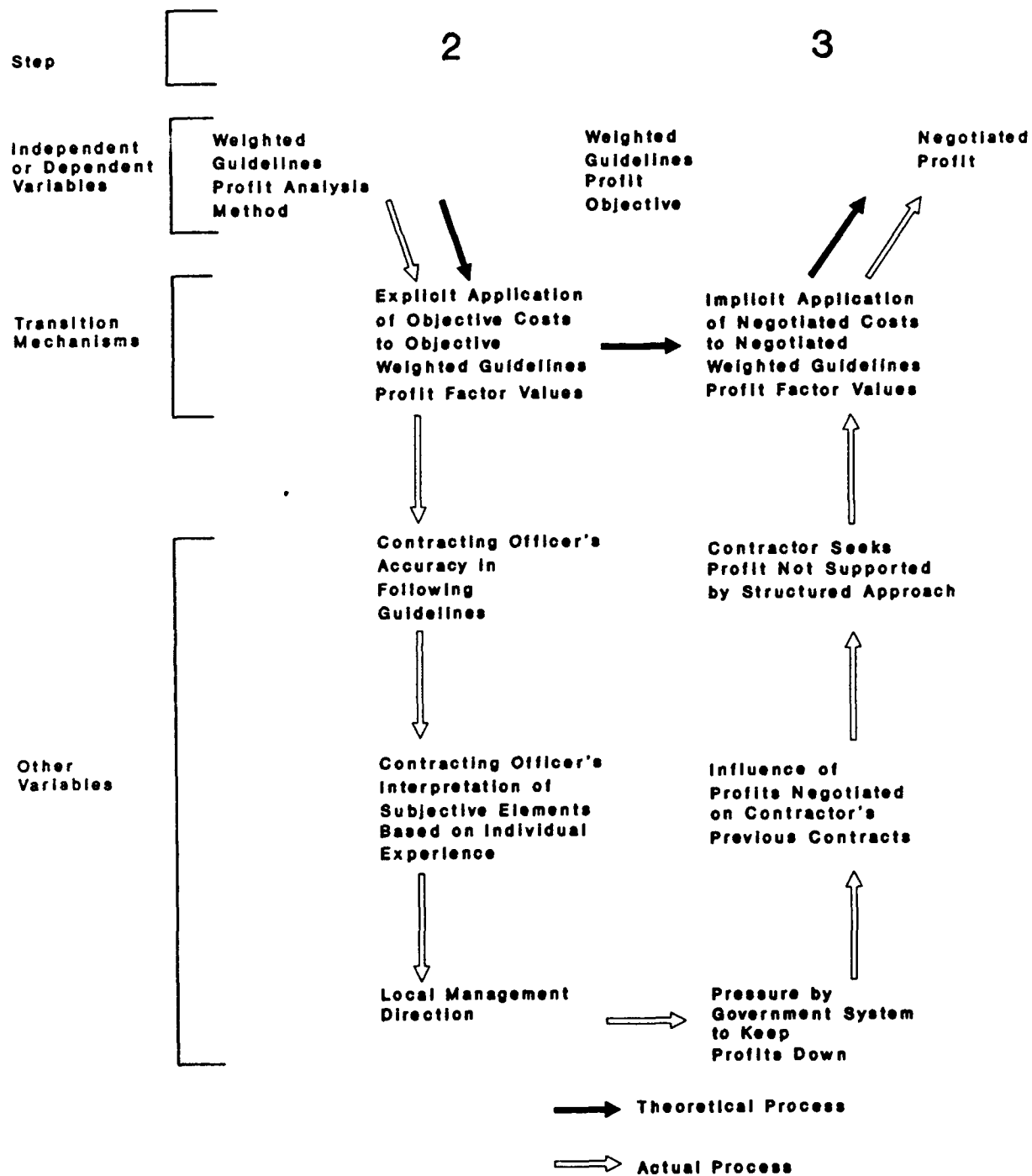


Figure 2. Defense Profit Process Steps 2 and 3

### Specific Problem Statement

The specific question that this thesis will address is whether or not the net effect of the 'Other Variables' is significant in the functional relationship between the independent variable 'Weighted Guidelines Profit Analysis Method' and the dependent variable 'Negotiated Profit'. In other words, taken as a group, are the 'Other Variables' in 'Step 2' and 'Step 3' moderating variables or extraneous variables.

### Method of Analysis

The approach was to measure process 'Steps 2 and 3'. Process 'Steps 2 and 3' were measured first with the influence of the 'Other Variables' and then without the influence of the 'Other Variables' to see if there was any difference in the two outcomes. The outcomes were a measure of the dependent variable 'Negotiated Profit'. To accomplish this analysis, process 'Steps 2 and 3' were divided into two sub-processes, the 'Actual Process' and the 'Theoretical Process'.

The 'Actual Process' is defined as moving from 'Weighted Guidelines' to 'Negotiated Profit' with the influence of the 'Other Variables'. This is described as the 'Actual Process' because it is felt that this process closely resembles the contracting environment experienced by contracting officers in the field.

The 'Theoretical Process' is defined as moving from 'Weighted Guidelines' to 'Negotiated Profit' without any 'Other Variable' influence to bias the weighted guideline criteria. This is described as the 'Theoretical Process' because it is thought that this process only

exists in theory.

In measuring both the 'Actual Process' and the 'Theoretical Process', the unit of measure for the dependent variable 'Negotiated Profit' will be the 'Z' score. The 'Z' score is a value which expresses the number of standard deviations an observed value departs from the mean. The 'Z' score for the average contract following the 'Theoretical Process' will be compared to the 'Z' score for the average contract following the 'Actual Process'. A difference in the two 'Z' scores is assumed to be a result of the influence of the 'Other Variables'. Because a sample of the population of contract profit 'Z' scores representing the 'Actual Process' was used rather than a census, a statistical hypothesis test was conducted to determine if the sample mean was significantly different than the 'Theoretical Process' population mean. A complete development of the 'Z' score is found in Chapter II and the measurement of the two processes will be covered in Chapter III.

#### Research Objective

Statement of Objective. The objective is to answer the three investigative questions and test the hypothesis.

Investigative Question #1. What profits were awarded on contracts for all goods and services acquired by DOD (see assumption #2)?

Investigative Question #2. For each of the contracts from Investigative Question #1, what is the population of possible negotiated profits (computed using negotiated costs and all combinations of profit factor values permitted by weighted guidelines)?

Investigative Question #3. What is the 'Z' score for each contract following the 'Actual Process' based on the negotiated profit from Investigative Question #1 and the population of all possible profits found in Investigative Question #2?

Hypothesis. The average 'Z' score for contract profits, when considering all goods and services acquired by DOD, following the 'Actual Process' equals the average 'Z' score for the 'Theoretical Process'.

#### Limitations of the Study

Assumption #1. Based on the Department of Defense supplement to the Federal Acquisition Regulation (DFAR) definition of normal value, the average contract when considering all goods and services acquired by DOD is expected to use the normal profit factor value.

The DFAR contains the following definition of normal value.

A normal value and designated range have been established for each profit factor. The normal value is the expected profit assignment where average conditions exist when compared to all goods and services acquired by DOD. (1:215.970)

Having stated this rule, the DFAR then provides three exceptions where for the particular application noted, the weighted guidelines instructions will not result in the normal value being the expected profit assignment.

Time and Materials Contracts. The DFAR gives the following guidance on profit assignments for time and material and other contracts.

Time and material contracts; labor hour contracts; overhaul contracts priced on a time and material basis; and firm-fixed-price-level-of-effort-term contracts shall be considered to be

cost-plus-fixed-fee contracts for the purpose of establishing a profit value for contract type risk. However, higher profit values within the designated range may be justified to the extent that portions of the cost are fixed. (1:215.9-8)

This exception could cause the expected profit assignment for cost-plus-fixed-fee contracts to be higher than the normal value.

Fixed Price Contracts with Redeterminable Provisions. The DFAR instructs that this type of contract should be considered as a fixed-price-incentive contract with below normal conditions. This exception could cause the expected profit assignment for fixed-price-incentive contracts to be lower than the normal value.

Foreign Military Sales. The DFAR gives the following guidance on profit assignments for Foreign Military Sales contracts.

In determining contract type risk, it is appropriate to consider additional risks associated with contracts for foreign military sales which are not funded by United States appropriations. The contracting officer may recognize additional risk if the contractor can demonstrate that there are substantial risks above those normally present in DOD contracts for similar items. (1:215.9-8)

This exception could cause the expected profit for contracts which includes foreign military sales to be higher than the normal value.

Time and material and foreign military sales contracts are not identified on the DD1547 therefore the exceptions could not be applied to the analysis. Fixed-price-redeterminable contracts are separately identified; however, the Fiscal Year (FY) 1989 database reported only one out of the total 2124 records. It is assumed that these three exceptions will not affect this assumption that some contracts will be assigned above normal profit factor values, some will be assigned below normal profit factor values, but the average contract is expected to be assigned the normal profit factor value.

Assumption #2. All goods and services acquired by DOD are adequately represented by fiscal year 1989 DOD negotiated contracts valued over \$500,000 contained in the DOD database under use codes '1', '2' and '3'.

The purpose of this research is to investigate whether the results of the 'Actual Process' differ from the results of the 'Theoretical Process'. It is demonstrated in the Methodology (Chapter III) that the expected result of the 'Theoretical Process' is based on the average contract for all goods and services acquired by DOD. The actual process is based on contracts actually negotiated. Because the universe for the 'Theoretical Process' includes all goods and services acquired by DOD, the universe for the 'Actual Process' must also include all goods and services acquired by DOD in order for the results of the two processes to be comparable. Amassing actual contract data for all goods and services acquired by DOD would be prohibitive. The universe of all goods and services acquired by DOD would include sealed bid as well as negotiated procurements spanning an unbounded number of years. The only profit data available in sufficient detail to be useful for this study is the Record of Weighted Guidelines Method Application (DD Form 1547) collected through the DOD wide management information system (1:204.673-1). The DD Form 1547 includes profit data for all negotiated DOD contracts valued over \$500,000. In order to use the Form 1547, an assumption is required that the DD Form 1547 profit data is equivalent to 'all goods and services acquired by DOD'. This assumption is supported by the fact that 95 percent of the total procurement value is composed of negotiated contracts (21:52).



The FY 89 DOD negotiated contracts valued over \$500,000 contained in the DOD database are further restricted to those contracts listed in the DOD profit database which are identified as use code '1' (Alternate Performance Risk), use code '2' (Standard Facilities Capital Employed), and use code '3' (Alternate Facilities Capital Employed). This assumption excludes contracts which were not reported and those that were identified as use code '4' (Alternate Structured Approach) and use code 5 (Modified Weighted Guidelines Method). The instructions for these profit analysis methods are documented in DFAR 215-902(a). The Alternate Structured Approach ( use code '4' ) does not use the DFAR profit factor values and does not document the normal value for the range used and therefore can not be analyzed using the 'Z' score. The Modified Guidelines procedure (use code '5') does not completely document on the DD1547 what use code, either '1', '2' or '3', it is based on; therefore, the normal values are not determinable and a 'Z' score is not possible.

Assumption #3. Weighted guidelines are used implicitly to arrive at negotiated profits.

The expected mechanism operating between the 'Objective Profit' and the 'Negotiated Profit' is the application of negotiated costs to negotiated weighted guideline profit factor values. This is defined as an implicit action because the DFAR does not require the contracting officer to recompute weighted guidelines using negotiated costs and negotiated profit factor values. In fact the DFAR states that the contracting officer shall not attempt to reach specific agreement on the applied weights or values for individual profit factors (1:215.903).

However, the DFAR does require that the final negotiated profit be based on negotiated costs (Line 35 of weighted guidelines) and the three components of profit recognized by defense profit policy: performance risk, contract type risk, and facilities capital employed (1:215.971). To the extent that profit policy is embodied by weighted guidelines, the final negotiated profit is a function of some combination of weighted guideline profit factors values and negotiated costs implicitly negotiated. The fact that the contracting officer and contractor do not have to agree which combination does not negate that the final negotiated profit is expected to be implicitly based on the guidelines and that through the negotiation process, the contracting officer continues to consider the weighted guideline components of profit in negotiating price.

Assumption #4. The "contracting officer's best estimate of cost and profit" in the negotiation summary section of the Record of Weighted Guidelines Method Application (DD Form 1547) is accurate.

In order for this to be true, costs must be negotiated separately from profits. This is true for cost type contracts but is less valid for fixed price contracts. Fixed price contracts are usually negotiated on the basis of total price (1:215.9-16). When contracts are negotiated based on total price, the ability to distinguish between cost and profit becomes less accurate.

Assumption #5. The database is complete, accurate, and correct.

The database is complete. All contracts which met the requirements for the reporting under the Profit Reporting Management Information System were reported.

The records are correct. There are no mathematical errors.

The records are accurate. The information on the DD 1547's is accepted as written. If the contract type is listed as 'J', firm fixed price, then all line items are assumed to be firm fixed price. If the contract type is listed as 'J' and the contract was definitized after most of the work was completed, it is assumed that the profit factor values for 'J' type contracts were still used.

A discussion of the accuracy and completeness of the FY 89 database is found in Chapter II.

#### Availability of Data

Negotiated Profits are documented on the Record of Weighted Guidelines Method Application, DD Form 1547. The DD1547's are prepared for all negotiated contracts over \$500,000 that require cost analysis and serve as the principle source document for reporting profit statistics to DOD's management information system (1:215.9-13). Each contracting officer is responsible for properly preparing the DD Form 1547 and forwarding a copy of it within 30 calendar days after the date of contract award to the appropriate service collection point. The service collection points edit and encode the forms and submit them quarterly via the DOD management information system.

The management information system is controlled by the Office of the Deputy Assistant Secretary of Defense (Procurement) Directorate of Cost Pricing and Finance. The management information system is maintained by the Office of the Secretary of Defense, Washington Headquarters Service,

Directorate for Information Operations and Reports. An agreement was reached with the Office of the Under Secretary of Defense (Procurement) Directorate of Cost, Pricing and Finance to use the database for the purpose of this thesis with the understanding that no results would be published that identified specific contracts or contractors.

## II. Background

### Introduction

The first part of the background will explain the Defense Profit Model, the second part will review literature covering the history of defense profit policy, the third part of the background will briefly cover the structure of weighted guidelines and the conditions for its use, and the final part will review the DOD profit data collection system.

### The Defense Profit Model

The Defense Profit Model (Figure 1) proposes that five steps exist between 'Defense Profit Policy' and its affect on the 'Strength of the Defense Industrial Base'. Each step includes an independent variable which is assumed to control the subsequent dependent variable through the transition mechanism indicated for that step. In the subsequent step the dependent variable becomes the independent variable and so the process continues. The first independent variable 'Defense Profit Policy' and the last dependent variable 'Strength of the Defense Industrial Base' were drawn from the goal of Defense Profit Policy. The independent and dependent variables which lie between were based on the following statement in the DOD Annual Profit Report. 'The profit objective is not equivalent to negotiated profit (amount included in the contract), or realized profit (amount ultimately earned)' (2:2). The 'Other Variables' and 'Transition Mechanisms' resulted from the 1986

Defense Financial and Investment Review, various other cited references and the authors personal experience. Each step in the model is described below.

Step 1: Defense Profit Policy - Weighted Guidelines Analysis Method.

Defense Profit Policy is described in the Department of Defense (DOD) Federal Acquisition Regulation (FAR) section 215.902. The policy is implemented through the Weighted Guidelines method of profit analysis as described in DOD FAR section 215.970. The Weighted Guidelines method is DOD's structured approach for performing the profit analysis necessary to develop a pre-negotiation objective. The degree to which weighted guidelines reflects profit policy is a direct result of how thoroughly the general policy is transcribed into the Weighted Guidelines Method. One "Other Variable" is introduced when situations are encountered in practice that are not covered by the weighted guidelines.

Step 2: Weighted Guidelines Method - Weighted Guidelines Profit

Objective. Prior to negotiation, the Defense Federal Acquisition Regulation requires contracting officers to calculate a weighted guideline profit objective by applying the objective costs to the appropriate weighted guideline profit factor values (1:215:903). This is the transition mechanism which is assumed to govern the relationship between the independent variable "Weighted Guidelines Profit Analysis Method" and the dependent variable "Weighted Guidelines Profit Objective". There are three "Other Variables" which may also impact on the transition between these two steps. These "Other Variables" are listed below.

Accuracy. Although the guidelines are well written, the contracting officer may not be completely accurate in following the weighted guideline instructions. It is possible that the accuracy with which the contracting officer follows the weighted guidelines could increase or decrease the expected 'Objective Profit.'

Interpretation. The contracting officer's interpretation of the subjective elements based on individual experience may affect the profit objective. Interpretation differs from accuracy in that accuracy identifies the ability of the contracting officer to select the correct range of profit factor values permitted by weighted guidelines. Interpretation identifies the basis on which each contracting officer selects a profit factor value from the allowable range. The guidelines state that the contracting officer should select a value from the range of profit factor values based on whether the contract conditions are 'above normal, normal or below normal'. The guidelines define 'normal' as 'the expected profit assignment where average conditions exist when compared to all goods and services acquired by DOD' (1:215.9-3). For each profit factor the weighted guideline instructions give a further explanation of below normal, normal, and above normal conditions. However, it is possible that the contracting officer will base normal on his own experience rather than the standard. The contracting officers interpretation of the subjective elements of weighted guidelines could increase or decrease the expected 'Objective Profit.'

Management Direction. Local management direction may affect the profit objective. The personnel survey portion of the 1986 Defense Financial and Investment Review reported that 'Over 55 percent of all

respondents agreed that the profit/fee objective is often dictated by management regardless of the weighted guideline computation" (3:90). Local management direction may either increase or decrease the expected "Objective Profit."

Step 3: Weighted Guidelines Profit Objective - Negotiated Profit.

The assumed mechanism operating between the "Objective Profit" and the "Negotiated Profit" is the application of negotiated costs to negotiated weighted guideline profit factor values. This transition mechanism was described in thesis assumption #3.

There are three "Other Variables" which have an effect on "Negotiated Profit." These variables are described below.

Contractor Approach. The method of analysis used by the contractor may affect the negotiated profit. The DOD recognizes three components of profit: performance risk, contract type risk, and facilities capital employed (1:215.9-16). These components are the basis of the weighted guideline method. On the other hand, contractors are not bound by weighted guidelines and may seek to negotiate a profit not supported by this particular structured approach. Contractors may quantify the components using some other method and target a company required internal rate of return. In the Defense Financial and Investment review personnel survey, "Ninety-One percent (91%) of all respondents agreed that regardless of Weighted Guidelines, contractors are out for a specific profit return on each contract" (3:99)

A differing contractor approach can either increase or decrease the expected "Negotiated Profit." While a decrease would be unusual it could occur where the contracting officer initially offers a profit



lower than the objective and the contractor accepts.

Profits of Previous Contracts. Contracting officers may be influenced by precedents set by previous negotiations with the contractor on similar contracts. In Defense Financial and Investment Review personnel survey, 'Seventy-one percent (71%) of all respondents agreed that negotiated profit rates are more closely related to profit rates negotiated with a particular contractor on previous contracts than they are to the weighted guideline objective' (3:82). Previously negotiated rates may increase or decrease the expected 'Negotiated Profit'.

Pressure within System. The process of negotiation may be viewed by some government contract management personnel as a zero sum game where higher profits translate into a loss of value to the government. This perception may cause pressure on contracting officers to keep profits down. The defense Financial and Investment Review reported 'Seventy-Five percent (75%) of all respondents agreed that the system puts a lot of pressure on contracting officers to keep profits down' (3:92). This perception may cause a decrease in the expected 'Negotiated Profit'.

Step 4: Negotiated Profits - Actual Profits. The negotiated profit is based on negotiated costs and the actual profit is based on actual costs. The assumed mechanism which transforms negotiated costs into actual costs is contract performance. A fixed price contract which results in actual costs less than negotiated costs will increase actual profit. Similarly, contractor performance which results in actual costs

greater than negotiated costs will decrease actual profit. With a cost type contract the contractor will always receive the largest return on investment by keeping costs down since profit as a percentage of cost type contracts are not permitted. Return on investment is a measure of the amount of profit earned by each unit of company resource per unit time. The more units of resource and time required (cost) the lower the return on investment. There are three 'Other Variables' which may affect the 'Actual Profit'.

Method of Accounting. Distinguishing between costs and profits in accounting is as difficult as distinguishing between needs and wants in economics. Although the cost accounting standards attempt standardize costs, they are not exhaustive and do not apply to all contractors. The difference between what is a cost and what is a profit remains a matter of perspective (22.48). For instance, company A operates inefficiently and manages a small profit for the year. Company B operates highly efficiently and the year end operations result in a large profit however those profits are converted to costs as a result of incentive bonuses paid to employees. Which company is more profitable?

Government Pricing, Financing and Tax Policies. Government pricing policies that affect the actual profit include disallowed costs and audit policies. For instance, the Federal Acquisition Regulation does not recognize lobbying costs as allowable costs therefore contractors must recover these costs from their profits (6:31.001). Government audits of overhead rates can also affect the actual profit through re-adjustment of the overhead rates after contract completion.

Government financing policy is recognized in the working capital

adjustment section of the weighted guidelines however the timeliness of Government payments is still uncertain and can impact cash flow and profits (16:18).

Government tax policies such as the corporate profit tax provides an incentive to keep actual profits down.

The combined effects of Government Pricing, Financing, and Tax Policies may either increase or decrease the expected 'Actual Profit'.

Change Orders. Subsequent agreements for engineering and contract change proposals are not bound by the profit rate of the existing contract (1:215-902). These orders may either increase or decrease the 'Actual Profit'.

Step 5: Actual Profit - Effect of Profit on Defense Industrial Base.  
The assumed mechanisms which transform the independent variable 'Actual Profit' into the dependent variable 'Strength of the Defense Industrial Base' are 'Capital Investment and the Entrance of New Suppliers'. It is expected that a decision by corporate management which compares 'Actual Profit' to the profitability of competing investments will result in the employment of its resources in the highest yielding investment. If actual profits from defense work are perceived to be higher than actual profits from other choices, then through reinvestment and entry of new suppliers, 'Actual Profits' will increase the 'Strength of the Defense Industrial Base'. There are two 'Other Variables' which may influence how 'Actual Profits' affect the 'Strength of the Defense Industrial Base'.

Ease of Entering and Exiting the DOD Supply Field. Although there may be a profit incentive to switch between capital and defense goods,

barriers to that transition exist (7:44). Barriers to entering include: the classified nature of some military procurements, perceived labyrinth of regulations, and resistance to allowing access to corporate records in accordance with the Truth in Negotiations Act. A barrier to exiting is the specialized equipment and skills required for some defense products which are not easily transferable to capital goods. The ease of entering or exiting the DOD supply field may enhance or detract from the effect of "Actual Profit" on the "Industrial Base."

Expected Value of Competing Investments. The decision by management to engage in the highest yielding investment is a forecast based on past actual profits. Because past profits are no guarantee of future returns, the decision may actually be made based on the expected value of future profits. The expected value is composed of the forecast profit multiplied by the probability that the forecast profit will be achieved. Whether future military orders are expected to be more or less predictable than capital goods may enhance or detract from the effect of "Actual Profit" on the "Industrial Base."

#### History of Defense Profit Policy

The developments in Defense Profit Policy will be presented in chronological order. For ease of presentation, the history is divided into three periods: Inception through World War II, Post World War II through the 1986 Defense Financial and Investment Review, Defense Financial and Investment Review to Present.

Inception Through WWII. In 1795, Congress enacted the Purveyor of Public Supplies Act which provided for the procurement of supplies for

defense. As early as 1809, the Congress became involved in regulating defense procurement by passing a statute requiring purchasing officers to advertise for competitive bids (21:52). It was not until WWI, however, that Congress attempted to regulate the profits of arms manufacturers by instituting an excess profits tax. At the conclusion of WWI, Congress was deluged with over 200 bills dealing with limiting wartime profits (8:11). The result was the Vinson-Trammel Act passed in 1934 which limited profits to 10 percent of the contract price. During WWII, this Act was suspended and replaced with the Renegotiation Act of 1942 which authorized the government to re-determine profits after contract completion. The re-determination was based on reasonableness of costs and a comparison of war and peacetime products (21:52).

Post WWII through 1983. The common thread through both the Vinson-Trammel Act and the Re-negotiation Act was that profit was based on a percentage of sales. In response to concerns that contractors were inflating their cost estimates to increase their profits, Congress passed the Truth in Negotiations Act of 1962. The Act which is still in effect requires contractors to certify that their costs are current, accurate, and complete when proposed (6:15.2). In order to standardize the basis on which contracting officers determined profit, the DOD adopted the first version of the weighted guidelines procedure in 1964 (18:57). The guidelines defined a range of profit for each different category of production costs.

Over the next several years, the idea of computing profits on some basis other than costs began to evolve. The following recommendation was included in the DOD Profit 76 Study.

Profit objectives are being developed as a percentage of expected costs which in the long run penalizes investments in cost reducing equipment. We recommend that guidelines be developed for determining profit objectives that emphasize consideration of the capital investment required to perform a contract. (8:13)

DOD adopted this recommendation by modifying the weighted guidelines to base 90 percent of the profit determination on cost factors and 10 percent on value of facility capital employed (21:52). In concert with this modification to weighted guidelines, Congress abolished the Re-negotiation Act in 1979 and the Vinson - Trammel Act in 1980, leaving profit policy as an administrative procedure for each agency and service to address (8:14).

Defense Financial Investment Review to Present. In 1983, the Secretary of Defense initiated a study of defense contractor profits in response to public distrust and suspicion resulting from a series of revelations regarding overpricing of seemingly common items like hammers, toilet seats, and coffee pots. The commission titled Defense Financial and Investment Review (DFAIR) was tasked with reviewing DOD procurement policy with the aim of maintaining a strong industrial base. A major emphasis of the review was defense profit policy. The Defense Financial and Investment Review concluded that previous policy had resulted in an unintentional increase in objective profit rates. The weighted guidelines profit policy was revised in 1987 to reduce objective profit rates by 1 percentage point (14:3) "This lead to the inclusion of certain changes, among which were an increase in the profit value assigned to performance risk, a lowering of the profit rate for facilities capital employed, and the exclusion of general and administrative expenses from the mark-up base" (14:5). The current

weighted guideline for profit determination reflects the changes recommended by DFAIR.

This brief review of Defense Profit Policy demonstrates that from WWI to the present, the U.S. Government has attempted to control the profits of defense contractors in order to achieve the defense profit policy goals of stimulating efficient contract performance, inducing capital investment, and attracting suppliers to the defense industrial base. The current method used to control profit is the Weighted Guidelines Profit Analysis method.

#### Weighted Guidelines

The weighted guidelines method is DOD's structured approach for rewarding risk, motivating efficient and quality performance, and stimulating capital investment in the defense industrial base (15.902). Its use is fully described in DFAR 15.970. This section will generally describe how the guidelines are structured.

The DD1547 "Record of Weighted Guidelines Application" Figure 3, is composed of three areas. The first area, lines 1 - 20, provides basic information about the contract being negotiated. The second area, lines 21 - 30 is the profit objective calculation and the third area, lines 31 - 36, is for profit reporting.

The second area is where the profit calculation takes place. There are two parts to the profit calculation; one part deals with contractor risk, and one part deals with facility capital employed. The contractor risk part covers performance risk (line 24), contract type risk (line 25) and the working capital adjustment (line 26). The other part,

RECORD OF WEIGHTED GUIDELINES APPLICATION						REPORT CONTROL SYMBOL DD - P&L(Q)1751		
1. REPORT NO		2. BASIC PROCUREMENT INSTRUMENT IDENTIFICATION NO			3. SPIIN		4. DATE OF ACTION	
		a. PURCHASING OFFICE		b. SY	c. TYPE PROC. INST. CODE	d. PRISM	e. YEAR	f. MONTH
5. CONTRACTING OFFICE CODE					ITEM	COST CATEGORY		OBJECTIVE
6. NAME OF CONTRACTOR					13	MATERIAL		
					14	SUBCONTRACTS		
7. DUNS NUMBER			8. FEDERAL SUPPLY CODE		15	DIRECT LABOR		
					16	INDIRECT EXPENSES		
9. DOC CLAIMANT PROGRAM			10. CONTRACT TYPE CODE		17	OTHER DIRECT CHARGES		
					18	SUBTOTAL COSTS (13 thru 17)		
11. TYPE EFFORT			12. USE CODE		19	GENERAL AND ADMINISTRATIVE		
					20	TOTAL COSTS (18 + 19)		
WEIGHTED GUIDELINES PROFIT FACTORS								
ITEM	CONTRACTOR RISK FACTORS		ASSIGNED WEIGHTING		ASSIGNED VALUE		BASE (ITEM 18)	PROFIT OBJECTIVE
21	TECHNICAL		%					
22	MANAGEMENT		%					
23	COST CONTROL		%					
24	PERFORMANCE RISK (COMPOSITE)							
25	CONTRACT TYPE RISK							
26	WORKING CAPITAL		COSTS FINANCED		LENGTH FACTOR	INTEREST RATE		
						%		
	CONTRACTOR FACILITIES CAPITAL EMPLOYED				ASSIGNED VALUE	AMOUNT EMPLOYED		
27	LAND							
28	BUILDINGS							
29	EQUIPMENT							
30	TOTAL PROFIT OBJECTIVE							
NEGOTIATION SUMMARY								
					PROPOSED	OBJECTIVE	NEGOTIATED	
31	TOTAL COSTS							
32	FACILITIES CAPITAL COST OF MONEY (DD Form 1861)							
33	PROFIT							
34	TOTAL PRICE (Line 31 + 32 + 33)							
35	MARKUP RATE (Line 32 + 33 divided by 31)				%	%	%	
CONTRACTING OFFICER APPROVAL								
36. TYPED, PRINTED NAME OF CONTRACTING OFFICER (Last, First, Middle initial)				37. SIGNATURE OF CONTRACTING OFFICER			38. TELEPHONE NO	39. DATE SUBMITTED (YYMMDD)
OPTIONAL USE								
96			97			98		99

DD Form 1547, AUG 87

Replaces DD Form 1547, 1-67

Figure 3. The Weighted Guidelines Form (DD1547)



facilities capital employed (lines 27-29) deals with the profit objective for the contractor's investment in buildings and equipment.

The column labeled "assigned value" is where the contracting officer uses his/her discretion in selecting a value from the range designated in the DFAR which is commensurate with the performance risk, contract type risk, financing arrangements, and facilities capital employed. The DFAR has a designated normal value for the contracting officer's discretionary values and defines normal as "the expected profit assignment where average conditions exist when compared to all goods and services acquired by the DOD" (1:15.970).

The discretionary values are then multiplied by sub-total costs (line 18) in the case of performance and contract risk. In the case of facilities capital employed, the discretionary assigned values are multiplied by estimates of the amount of facilities capital employed for the effort anticipated on the contract. These estimates are provided by an auditor on a DD1861. The procedure to arrive at this estimate is found in DFAR 30.7004.

The resultant profit objective (line 30) is a factor of contract costs, estimates of facilities capital employed, the DFAR designated range, and the contracting officer's judgement.

#### The FY89 Profit Data Collection System

The Weighted Guidelines Application (DD1547) serves as the principle source document for reporting profit statistics through DOD's management information system (1:15.970). The contracting officers are required to send the completed DD1547 to their field activity point of contact and

then on to the service's designated collection point within 30 days of contract award. The designated collection point for each service is required to audit the DD1547's to ensure accuracy and then forward the information to OSD. The method used by each of the services to collect the FY89 profit data used in this research is covered below. Following the methods are the problems which have a bearing on the completeness and accuracy of the database used for this research. This section will conclude with actions currently being taken to improve the completeness and accuracy of the profit data collection system.

The Air Force Method. Each of the field contracting activities in the Air Force has a point of contact who is responsible for collecting DD1547's every 30 days, checking for errors and omissions, and forwarding them to HQ AFLC/SORS, the Air Force designated collection point. When the forms are received, they are keyed in to a COBOL program written by AFLC. This program puts the DD1547 information in the appropriate tape position and also checks for errors. The error check searches for mathematical errors, weighted guideline factors out of their designated range, and entries inconsistent with the contract type. When errors are found, the program prints a list of the DD1547's with an error message. HQ AFLC/SORS returns these DD1547's to the field contracting activities for correction along with those from the previous submission which OSD has identified as deficient. The records that have passed edit are forwarded to OSD before the end of the quarter. The records returned to the field activities for correction are included in the subsequent quarter's submission (24:-).

The Army Method. Each contracting field activity in the Army has a point of contact who is responsible for collecting DD1547's every 30 days and reporting them to the Department of the Army SFRD-KS. Every quarter this office does a preliminary visual error check and sends the forms to a contractor who enters the data in the appropriate magnetic tape format and runs an error check. The contractor returns the forms, an error listing, and a formatted magnetic tape containing the records which have passed edit. The records identified on the error listing are returned to the field activities for correction (17:-).

The Navy Method. Each Navy contracting officer has a database micro computer program which displays the DD1547 on the monitor. As the contracting officer makes entries, the program performs the calculations and prints out a completed form. This program also edits the form for incorrect entries as it is being filled out and identifies errors as they are made. The point of contact at each Navy field contracting activity compiles the records on a floppy disk and mails it to the designated collection point, Department of the Navy NAVSUP 0249. This office forwards the disks to the contractor that wrote the database micro computer program and the contractor forwards a single floppy disk to OSD. The Cognizant OSD office developed a program which makes this floppy disk format compatible with their HP3000 IMAGE data base (5:-).

Data Collection at The Office of the Secretary of Defense (OSD). The data from the services is fed in to the IMAGE database on a Hewlett Packard 3000 mini computer. The cognizant office at OSD, the Directorate for Information Operations and Reports (WHS/DIOR), has requested that each of the service collection points forward their data

on nine track ASCII magnetic tape formatted such that each item on the DD 1547 corresponds to a specific tape position. This sequential file structure is loaded into the HP 3000 and the data is transferred to flat files for random access. An edit program searches the records for errors and those records with errors are identified in a printout and deleted from the database. The printout is sent to the designated service collection point for correction.

Problems with the FY89 Database. The current profit management information system has several problems which will impact the accuracy and completeness of the FY 89 profit data used in this research.

Accuracy of Air Force profit reporting has been a continuing problem since the new Weighted Guidelines Method was introduced. A SAF/AQCP study completed in September 1989 revealed fully 40% of the DD Form 1547s submitted failed to pass a visual quality check. This check involves ensuring blocks 1-12 are completed, the objective and negotiated amounts entered, and the form signed and dated. Many reports also failed the check because they were illegible. Of the 60% of the reports that pass the visual check, only 77% pass the AFLC/LMSC computer relational and mathematical checks. Simply stated, for every 100 reports submitted, only 46 are actually sent to DOD. Consequently, Air Force profit statistics are grossly understated. (9:1)

The problems are encompassed by the six general problems commonly found in management information systems (9:641)

Job Duplication. In the Army and Air Force systems, the job of inputting the DD1547 information is performed twice. Once by the contracting officer on the paper form and again by the data entry clerk at the service's designated collection point. There is no value added by the clerk's job. In fact there is a strong possibility of errors being created as the clerk transcribes the information from the paper copy to the magnetic tape. The Navy system bypasses this additional step by

saving the contracting officers original entry in a computer readable format.

Job Overlap. All the systems contain several edit steps as the DD1547 progresses from the contracting officer's desk to OSD. In the Army and the Air Force, the field activity point of contact performs a visual check, the designated service collection point does both a visual and a computer edit, and OSD runs a computer edit. Even in the Navy's system, OSD runs a different edit and generates rejects. Unfortunately, the further along in the process the error is found, the longer it takes to return the form to the contracting officer for correction. Job overlap could be eliminated if the attributes of all the various edits were combined into one edit program which could be run on the micro computer at the field activity.

Job Inconsistencies. In the Air Force system the DD 1547 does not pass through the hands of someone familiar with contracting after it leaves the field activity. The people at AFLC/SORS are data processing experts as are the people at the Directorate for Information Operations and Reports at OSD. As a result of being unfamiliar with contracting, all edit rejections are returned to the field activities.

Paperwork Bottleneck. A single person at AFLC/SORS is responsible for collecting the DD1547's, returning errors and forwarding the formatted magnetic tape. When this person went on sick leave for two months profit reporting stopped.

Lack of Control Procedures. One of the services reported an edit rejection rate of up to 54 percent at the designated service collection point (9:1). Yet none of the services have a method of tracking whether

the DD1547's returned to the field activities for correction are ever actually corrected and returned to the system.

Inaccuracies. There is no check made to determine if all contracts requiring DD1547's are in the database. There is an established management information system (DD350) which collects source and cost data on all contracts over \$25,000. The contracts involved in the profit reporting system (negotiated, over \$500,000) are a subset of that group. There are no cross checks between the databases to determine if for every DD350 contract meeting the "negotiated, over \$500,000" criteria, there exists a DD1547.

Improving the Profit Data Collection System. In order to address the problem, a joint effort between Headquarters Air Force/AQCP and Aeronautical Systems Division/PMR resulted in a micro-computer based software program called WGL. "WGL is a fast and powerful stand alone application program for preparing the DD Form 1547" (9:1). The WGL program is a solution based on the operations management principle of "Make it easy to provide goods and services without error" (20:23). As stated in the WGL instruction book:

The cause of Air Force profit reporting problems is not insufficient management attention, rather it is lack of education and training, timely feedback, and attention to detail at the buying team level. The WGL program satisfies this need by providing on-line instruction into virtually every aspect of preparing the DD Form 1547. It also provides essentially the same relational and mathematical checks as the AFLC/LMSC computer. The program is customized for each buying office and speeds preparation of the form by automatically entering data that does not often change such as the interest rate and buying office code. It also automatically calculates selected fields and provides a clean error free report. (9:2)

Summary. The Office of the Secretary of Defense through the Department of Defense Federal Acquisition Supplement has outlined the

requirements for the profit reporting system. Each service has independently developed their method for getting the DD1547 information from the contracting officer's desk to the OSD. The Navy appears to have the most efficient system in that the data is input and edited at the source, however that system is contractor supported. The Air Force has developed and is now implementing similar software which like the Navy system will perform relational and mathematical checks at the point of entry thereby eliminating the input and edit function at the service collection point.

### III. Methodology

#### Introduction

The purpose of this thesis was to determine if the net effect of the 'Other Variables' on the negotiated profit was statistically significant. The method of determining the net effect was to measure the profit process 'Steps 2 and 3' with and without the influences of the 'Other Variables'. The results of the measurement were then compared. The process path which includes the 'Other Variables' is shown by the unfilled arrows in Figure 4 and is defined as the 'Actual Process'. The results of the 'Actual Process' are derived from actual contract data. Based on thesis assumption #2, FY 89 DOD negotiated contracts valued over \$500,000 and contained in the DOD database under use codes '1', '2', and '3' will be used as the basis for the 'Actual Process'.

The process path which does not include the 'Other Variables' is shown by the filled arrows in Figure 4, and is defined as the 'Theoretical Process'. The results of the 'Theoretical Process' are on average, the normal profit factor values applied to negotiated costs. This definition follows from thesis assumption #1. The 'Theoretical Process' is only defined for the average contract because only in the average contract is the normal profit factor value the expected assignment. The unit of measure for both the 'Theoretical Process' and the 'Actual Process' will be the 'Z' score. The methodology section will start with a justification for use of a 'Z' score to compare the



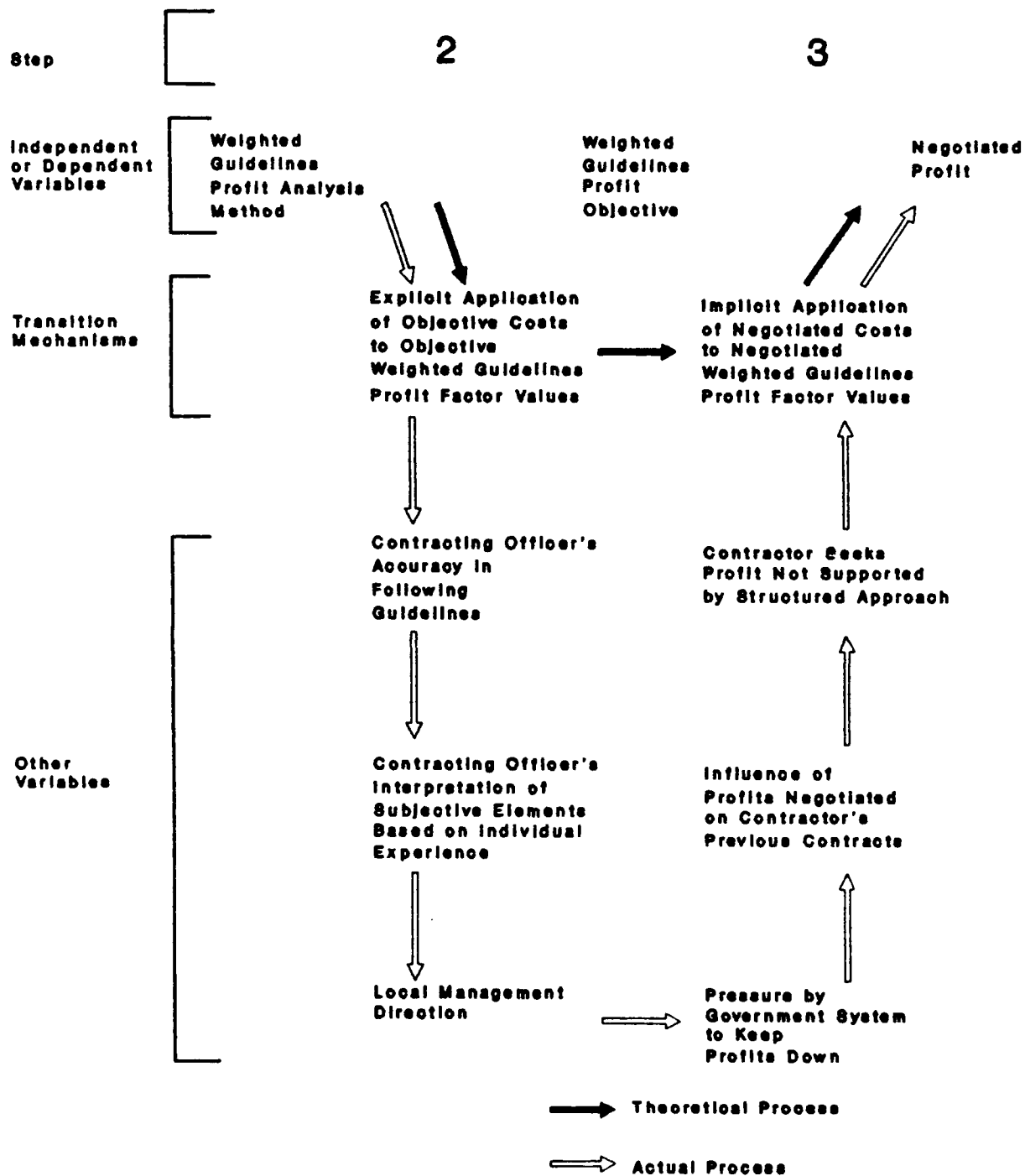


Figure 4. The Defense Profit Process Steps 2 and 3

'Actual Process' and the 'Theoretical Process'. Next, the methodology for each of the three investigative questions will be covered. The methodology section will conclude with a description of the hypothesis test.

#### Justification for Using 'Z' Score

In order to determine the net effect of the 'Other Variables' on 'Negotiated Profit', some method of comparison between the 'Actual Process' and the 'Theoretical Process' was required. Three methods concluding with the 'Z' score are discussed below.

Comparison of Profits for Single Contracts. The 'Theoretical Process' is represented by the profit calculated using weighted guidelines normal profit factor values multiplied by the negotiated costs on the average contract. The 'Actual Process' is represented by the profit negotiated by the contracting officer under actual conditions as reported on the DD1547. While the profit negotiated by the contracting officer is readily available through the DOD management information system, the 'Theoretical Process' for a single contract is undefined. Therefore comparing profits resulting from the 'Theoretical Process' and the 'Actual Process' within individual contracts is not possible.

Comparison of Weighted Guideline Profit Factor Values. Given that a comparison of individual contracts is inadequate, a second approach would be to compare the average weighted guideline profit factor values for each individual profit factor. The 'Theoretical Process' would be represented by the normal values for each profit factor. The 'Actual

Process' would be represented by the average of the weighted guideline profit factor values selected by contracting officers for each profit factor.

The following example illustrates the analysis of the individual profit factor 'contract type risk' using the values for a firm fixed price contract with no working capital adjustment using Standard Facilities Capital Employed (Use Code 2) or Alternate Facilities Capital Employed (Use Code 3).

In the 'Actual Process' the weighted guideline value for each profit factor would be averaged over all similar types of contracts. In this case the designated range of values is ( 4%, 5%, 6% ) the normal value for this designated range is 5 percent. This example, which is shown in Table 1, demonstrates the result of the 'Actual Process' for the profit factor 'contract type risk' with a Firm Fixed Price, no working capital, use code '1' or '2' contract.

Table 1  
Weighted Guideline Profit Factor Value Analysis

<u>Contract #</u>	<u>Value Selected by Contracting Officer</u>	
1	6	
2	4	
3	5	
4	<u>5</u>	
	20	Average = $20/4 = 5$

In the 'Theoretical Process' the weighted guideline value for each profit factor averaged over all contracts would by thesis assumption #1 equal the normal value. The normal value in the case shown in Table 1 is defined as 5 percent. To compare the two processes, if the average of the weighted guideline profit factor values which followed the 'Actual Process' (5 percent from table 1) equaled the normal value (5 percent) then it could be assumed that the 'Other Variables' have no net effect on the contract type risk profit factor utilizing a Firm Fixed Price contract with no working capital, for weighted guidelines use codes '1' or '2'.

There are two problems with this approach. First, profit factor values can only be compared for the particular profit factor application. There are so many designated ranges of profit factors depending upon contract type, working capital, and use code, that the over-all impact of differences within individual profit factors is difficult to gauge. Variance between actual and normal profit factor values are shown in the DOD profit annual report using the objective weighted guideline profit factor values (2:31-37). The second, more important limitation for this research is that negotiated profit factor values do not exist. They are only implicitly negotiated (assumption #3) and only the result of their application in the form of the negotiated profit is recorded.

Comparison of the Average 'Z' Scores Between the Two Processes. A measure of negotiated profit is needed that is based on the average contract and applies across all profit factors (performance risk, contract type risk, etc.). The 'Z' score which is based on the normal

distribution of profit possibilities within each contract meets these criteria. A 'Z' score is a value which expresses the number of standard deviations an observed profit departs from the mean of the population of profits. The normality of the distribution of profit possibilities is demonstrated in the methodology for Investigative Question #3.

Overview of 'Z' Score for the 'Theoretical Process'. A 'Z' score for an individual contract following the 'Theoretical Process' is undefined because there are no individual observed profits. In the 'Theoretical Process' the observed profits are only defined for the average of all contracts as is the normal profit factor value. When comparing all goods and services acquired by DOD, the average 'Z' score equals zero.

Overview of 'Z' Score for the 'Actual Process'. A 'Z' score for an individual contract following the 'Actual Process' identifies the number of standard deviations that the contracting officer's negotiated profit is from the mean of the distribution of all possible profits. The average 'Z' score when compared to all goods and services acquired by DOD equals the sum of the 'Z' scores for individual contracts divided by the number of contracts.

Overview of Comparison between the 'Theoretical Process' and the 'Actual Process'. Based on the hypothesis that the 'Other Variables' have no net impact, it is expected that the result of the 'Actual Process' will equal the result of the 'Theoretical Process'. The comparison between the 'Theoretical Process' and the 'Actual Process' is then performed by comparing the average 'Z' score for the 'Theoretical Process' (zero) to the average of all contract profit 'Z' scores.

This concept that the value of the average contract profit 'Z' score

following the 'Theoretical Process' is zero, and that the average 'Z' score for contracts following the 'Actual Process' is measurable, and that any difference between the average profit 'Z' score for the two processes represents the impact of the 'Other Variables' is key to this thesis. This concept for the 'Theoretical Process' and for the 'Actual Process' and will be explained graphically below.

Concept of 'Z' Score for the 'Theoretical Process'. For illustration purposes, assume that all goods and services acquired by DOD are represented by three contracts. The profit frequency distributions of these three hypothetical contracts are shown in Figure 5. The distributions are identified using the shorthand form  $N(\mu, \sigma)$  which first identifies the family of distributions, normal in this case, and the parameters,  $\mu$  (mean) and  $\sigma$  (standard deviation).

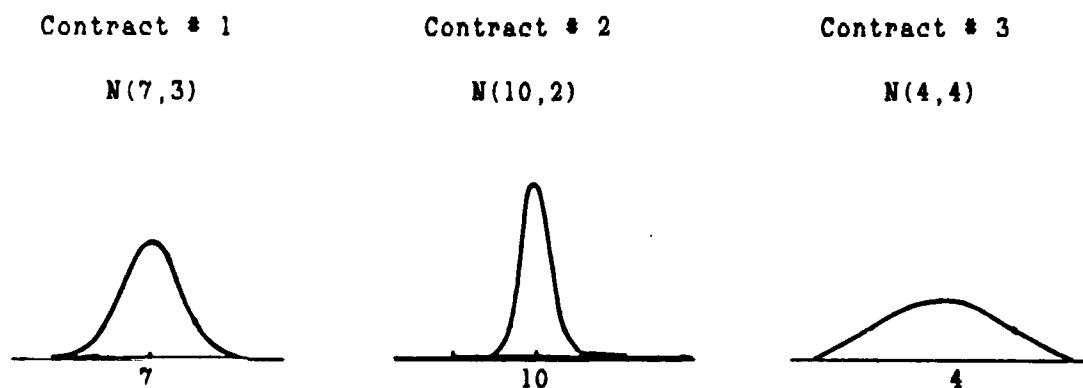


Figure 5. Three Hypothetical Contracts following the 'Theoretical Process'

The distributions represent all possible profits computed using negotiated costs and all combinations of profit factor values permitted by weighted guidelines for that contract application. These possible

profits are normally distributed as will be demonstrated in the methodology for Investigative Question #3 (Chapter III). Although the profit distributions for each contract are members of the family of normal distributions, each contract will have unique mean ( $\mu$ ) and standard deviation ( $\sigma$ ) parameters. Each distribution is unique because it arises from unique negotiated costs and unique weighted guideline profit factor value designated ranges.

The mean ( $\mu$ ) represents the average profit in the distribution and it also represents the profit which would be computed using the weighted guideline normal profit factor value from each profit factor range given in DFAR. The observation that the average profit from each profit distribution equals the result of the weighted guideline computation using the normal value from each designated range will be demonstrated in the methodology for Investigative Question #3 (Chapter III). The terms average profit and profit computed using normal profit factor values will be used interchangeably. The standard deviation ( $\sigma$ ) represents the dispersion of profits which are possible using the full designated range for each profit factor value.

Somewhere in the distribution of possible profits, based on assumption #3, is the negotiated profit that the contracting officer and contractor agreed was appropriate for this particular contract. This actual negotiated profit is designated as X on the hypothetical contracts shown in Figure 6.

In the 'Theoretical Process', each X represents the profit negotiated without the influence of 'Other Variables'. Although the X's are shown in Figure 6, the actual values of X resulting from the 'Theoretical

Process' are unknown. It is only known by assumption #1 that some are above normal, some are below normal, but the average contract when

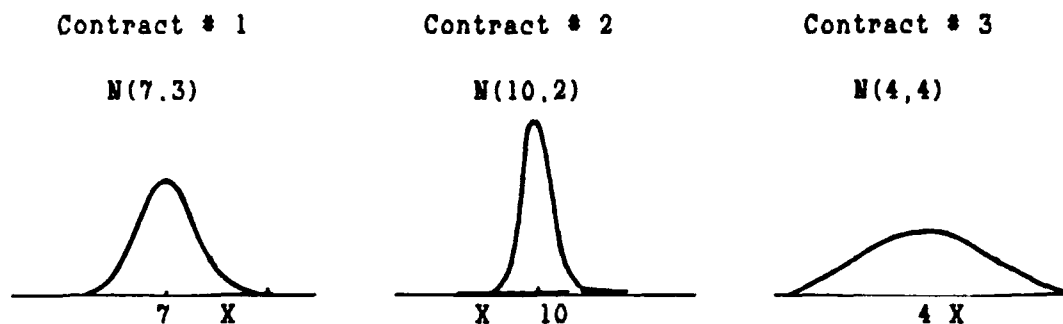


Figure 6. Three Hypothetical Contracts following the 'Theoretical Process' with Profit Negotiated (X)

considering all goods and services acquired by DOD is expected to use the normal profit factor value. This is the basis for stating that the profits ( the various X's ) following the 'Theoretical Process' can only be described in terms of the average contract. The average contract can be represented by the standardized normal distribution. The standardized normal distribution describes the X values in terms of how many standard deviations they are away from the mean (10:215). The random variable 'X' is transformed into the random variable 'Z' using the 'Z' transformation  $Z = (X - \mu) / \sigma$  where X represents the 'Negotiated Profit',  $\mu$  represents the mean of the distribution of profits, and  $\sigma$  represents the standard deviation of the distribution of profits.

If each contract following the 'Theoretical Process' were transformed into the standardized normal form, the mean ( $\mu$ ) by definition of the standard normal transformation would equal zero. Even though it has been transformed by the normal random variable 'Z', the mean still



represents the result of the weighted guideline computation using the normal values from each designated range. The standard deviation would equal 1 and the 'X' value representing the profit negotiated without the influence of the 'Other Variables' is now represented by a 'Z' value which identifies the negotiated profit in terms of how many standard deviations the various negotiated profits are away from the mean.

Again by assumption #1 it is only known that some 'Z' values are above the mean, some are below the mean, but the average contract 'Z' value when considering all goods and services acquired by DOD is expected to equal the mean. The mean of the 'Z' distribution represents the weighted guideline computation using the normal values for each designated range. The three hypothetical contracts transformed to the standard normal form appear as Figure 7 .

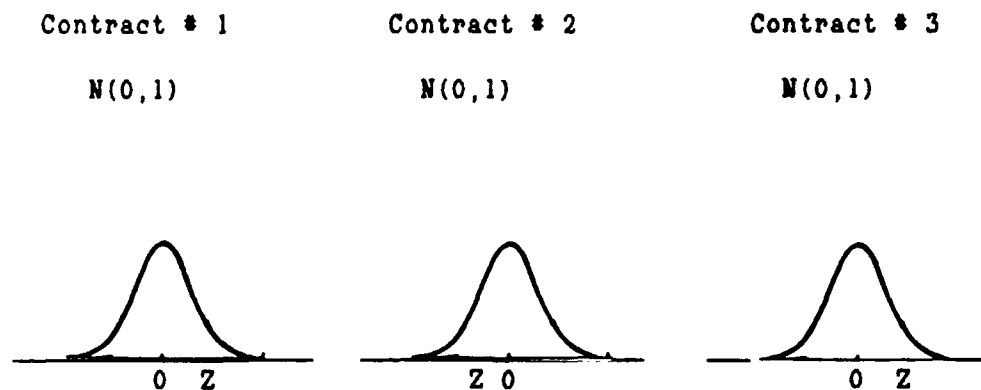


Figure 7. Three Standardized Normal Hypothetical Contracts following the 'Theoretical Process' with Profit Negotiated (Z)

The 'Z' values representing the negotiated profits resulting from the 'Theoretical Process' are still unknown. The 'Theoretical Process' is only defined in terms of the average contract when considering all goods and services acquired by DOD. However, a representation of the average

contract is now available by averaging the unknown 'Z' values. It is known by Assumption #1 that the average contract utilizes the normal profit factor values and that the normal profit factor values result in a profit 'Z' score of zero. The 'Z' values vary but based on assumption #1, the average 'Z' value will equal the mean. The average contract following the 'Theoretical Process' is illustrated in Figure 8.

### Profits for All DOD Contracts

Distribution Unknown

---


$$\begin{aligned}\mu_T &= 0 \\ \sigma_T &= \text{Unknown}\end{aligned}$$

Figure 8. The Average Hypothetical Contract following the 'Theoretical Process'

The mean of the 'Theoretical Process' can also be explained using the following logic:

1. Normal profit factor values produce a 'Z' score of zero (Proof in methodology for Investigative Question #3)
2. The normal profit factor value is the expected profit assignment where average conditions exist when compared to all goods and services acquired by DOD (1:215.970).
3. Average conditions are represented by the average contract for all goods and services acquired by DOD (assumed).
4. The average contract is represented by the average of all contract 'Z' scores (assumed).

5. The average of all contract 'Z' scores should produce a 'Z' score of zero (Based on statements 1 and 4).

Based on assumption # 1, and the discussion above, the value of the average contract profit 'Z' score following the 'Theoretical Process' ( $\mu_T$ ) is zero.

Concept of a 'Z' Score for the 'Actual Process'. Similar to the description of the 'Theoretical Process', assume that all goods and services acquired by DOD are represented by the same three contracts. Somewhere in the distribution of possible profits, based on assumption #3, is the negotiated profit the contracting officer and the contractor agreed was appropriate for the particular contract. The actual negotiated profit is designated as X in the hypothetical contracts shown in Figure 9.

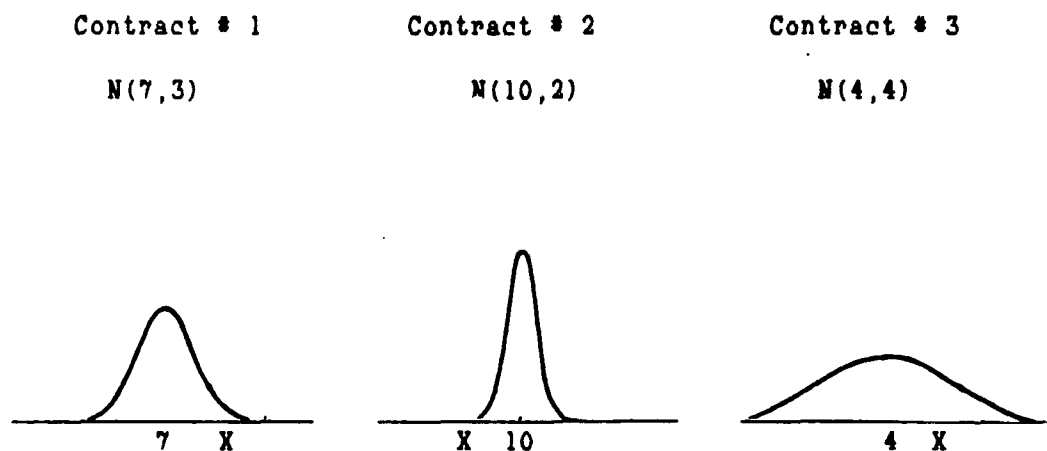


Figure 9. Three Hypothetical Contracts following the 'Actual Process' with Profit Negotiated (X)

In the 'Actual Process', each X represents the profit negotiated with the influence of the 'Other Variables'. The values of X following the 'Actual Process' are known and available through the DOD management

information system. In order to compare the results of the 'Actual Process' to the 'Theoretical Process', the results must be put in the same form. The only form in which the 'Theoretical Process' can be defined is the average of the standard normal random variable 'Z'. The results of the 'Actual Process' must be put in this form to allow a comparison of the 'Actual Process' and the 'Theoretical Process'.

The first step is to transform the results for the 'Actual Process' into the standardized normal form. The results of the 'Z' transformation on the three hypothetical contracts are shown in Figure 10.

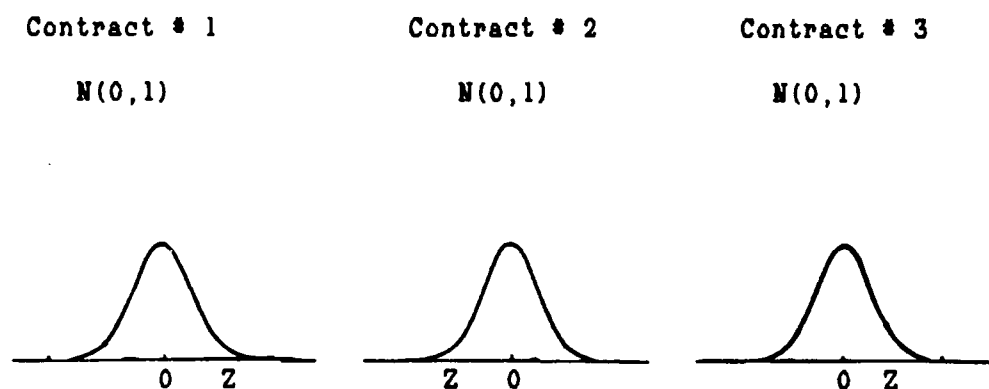
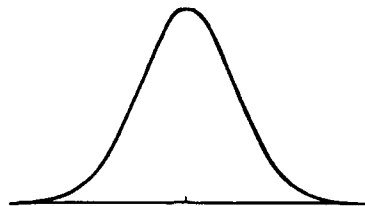


Figure 10. Three Standardized Normal Hypothetical Contracts following the 'Actual Process' with Profit Negotiated (Z)

The second step is to create a distribution of the individual profit 'Z' scores. It will be shown in the Chapter IV that these 'Z' scores are normally distributed. The mean of this distribution is the mean of the population of 'Z' scores for contracts following the 'Actual Process' ( $\mu_A$ ). The population mean ( $\mu_A$ ) is the number of standard deviations that the negotiated profit on the average contract is away from the mean. This 'Actual Process' population mean ( $\mu_A$ ) is comparable to the

'Theoretical Process' population mean ( $\mu_T$ ) described in the previous section. The population standard deviation ( $\sigma_A$ ) is a measure of the dispersion of the individual contract profit 'Z' scores. The average profit 'Z' score ( $\mu_A$ ) for the hypothetical contract following the 'Actual Process' is shown in Figure 11.

#### Profits for All DOD Contracts



$\mu_A$  = To be determined from data  
 $\sigma_A$  = To be determined from data

Figure 11. The Average Hypothetical Contract following the 'Actual Process'

In order to use the 'Z' score comparison, the following must also be known for each contract: the negotiated profit, the negotiated costs, and the applicable range of weighted guideline profit factor values. This information is available on the Record of Weighted Guidelines Analysis (DD 1547).

#### Methodology for Investigative Question # 1

The first investigative question was: What profits were awarded on contracts for all goods and services acquired by DOD?

In order to answer this question, the universe of contracts must first be defined.

Universe. The universe of contracts to be considered when evaluating weighted guidelines is all goods and services acquired by DOD (DFAR 215.9-3). Based on thesis assumption #2, all goods and services acquired by DOD are adequately represented by FY 89 DOD negotiated contracts valued over \$500,000 and contained in the DOD database under use codes '1', '2' and '3'.

This universe of contracts is described in the Fiscal Year 89 Department of Defense Contract Profit Report and identified by profit analysis method used as shown in Table 2.

The universe of contracts was received from the Washington Headquarters Service, Directorate of Information Operations and Reports on seven five and one quarter inch diskettes written in ASCII format with 628 characters per record. In accordance with assumption #2, the universe is represented by the 2124 records contained in the database which were identified by use codes '1', '2' and '3'. The defined universe represents 89 percent of the contract actions in FY 89.

Population. A population is a characteristic of a universe. The population required for Investigative Question #1, based on the universe of contracts described in the previous section, was the population of negotiated profits. Negotiated profit was represented by a field in each record. Each of the 64 blocks on the DD Form 1547 was represented by one of the 64 fields in the universe of 2380 records. Each field from a record represented a population such as negotiated profit. There were other populations such as contract #, subtotal cost, etc. required for both record identification and 'Z' score computation. Although these

Table 2

## Universe of Contracts Identified by Use Code (2:4)

<u>Use Code</u>	<u>Method</u>	<u>Actions</u>	<u>% Total Actions</u>	<u>PART OF UNIVERSE?</u>
1	Alternate			
	Performance Risk	319	13	yes
2	Standard			
	Facilities Capital			
	Employed	1685	71	yes
3	Alternate			
	Facilities Capital			
	Employed	120	5	yes
4	Alternate			
	Structured Method	210	9	no
5	Modified Weighted			
	Guidelines	<u>46</u>	<u>2</u>	no
		2380	100	

other populations were not strictly required to answer Investigative Question #1, they were required for subsequent investigative questions and the process of extracting these populations from the universe is covered here.

The objective of extracting populations from the universe, or fields from the records, was to satisfy the requirements of a MATHCAD template designed to produce a 'Z' score for each contract. MATHCAD is a software program for calculation and analysis produced by MathSoft

Corporation. Only those populations (fields) necessary to produce these 'Z' scores were extracted from the database. Fields not necessary to produce a 'Z' score were excluded in order to keep each record under 240 characters. This was a restriction of the microcomputer software which was used in this analysis. The populations (fields) required for calculating a 'Z' score are identified as filled blocks on the DD1547 included as Figure 12.

With the necessary fields identified, the universe of records was reduced to include only those populations (fields) necessary for the 'Z' score computation. The 2124 records of ASCII data were imported into WORDPERFECT. WORDPERFECT is a word processing product of the Word Perfect Corporation. Each of the records was edited by deleting fields not required and inserting comas and quotes between fields. The purpose of commas and quotes was to allow importing the reduced records into a spreadsheet program. A macro program was developed within the WORDPERFECT software to perform this editing. After edit, each record contained the 19 cost, profit and identification populations (fields) required for the 'Z' score computation. Each record after edit contained 220 characters which was under the 240 character limit.

The universe consisted of 2124 DD1547 records. Within each record were the 19 populations (fields) which were required to compute a 'Z' score.

Sample. A sampling approach rather than a census was chosen based on a test of the computer time required. Using the MATHCAD template and the data from one record, a Z-248 microcomputer equipped with a math co-processor required approximately 3 minutes to compute a 'Z' score.



RECORD OF WEIGHTED GUIDELINES APPLICATION					REPORT CONTROL SYMBOL DD - FORM 1547	
1. REPORT NO.		2. BASIC PROCUREMENT INSTRUMENT IDENTIFICATION NO.			3. SPIN	
a. PURCHASING OFFICE		b. FY	c. TYPE PROC INST CODE	d. PRISM	4. DATE OF ACTION	
					a. YEAR	b. MONTH
5. CONTRACTING OFFICE CODE				ITEM	COST CATEGORY	OBJECTIVE
6. NAME OF CONTRACTOR				13.	MATERIAL	
7. DUNS NUMBER				14.	SUBCONTRACTS	
8. FEDERAL SUPPLY CODE				15.	DIRECT LABOR	
9. DOD CLAIMANT PROGRAM				16.	INDIRECT EXPENSES	
10. CONTRACT TYPE CODE				17.	OTHER DIRECT CHARGES	
11. TYPE EFFORT				18.	SUBTOTAL COSTS (13 thru 17)	
12. USE CODE				19.	GENERAL AND ADMINISTRATIVE	
				20.	TOTAL COSTS (18 + 19)	
WEIGHTED GUIDELINES PROFIT FACTORS						
ITEM	CONTRACTOR RISK FACTORS	ASSIGNED WEIGHTING	ASSIGNED VALUE	BASE (ITEM 18)	PROFIT OBJECTIVE	
21.	TECHNICAL	%				
22.	MANAGEMENT	%				
23.	COST CONTROL	%				
24.	PERFORMANCE RISK (COMPOSITE)					
25.	CONTRACT TYPE RISK					
26.	WORKING CAPITAL	COSTS FINANCED	LENGTH FACTOR	INTEREST RATE		
	CONTRACTOR FACILITIES CAPITAL EMPLOYED			ASSIGNED VALUE	AMOUNT EMPLOYED	
27.	LAND					
28.	BUILDINGS					
29.	EQUIPMENT					
30.	TOTAL PROFIT OBJECTIVE					
NEGOTIATION SUMMARY						
		PROPOSED	OBJECTIVE	NEGOTIATED		
31.	TOTAL COSTS					
32.	FACILITIES CAPITAL COST OF MONEY (DD Form 1861)					
33.	PROFIT					
34.	TOTAL PRICE (Line 31 + 32 + 33)					
35.	MARKUP RATE (Line 32 + 33 divided by 31)	%	%	% %		
CONTRACTING OFFICER APPROVAL						
36. TYPED/PRINTED NAME OF CONTRACTING OFFICER (Last, First, Middle Initial)		37. SIGNATURE OF CONTRACTING OFFICER		38. TELEPHONE NO	39. DATE SUBMITTED (YYMMDD)	
OPTIONAL USE						
40.	41.	42.	43.	44.		

Figure 12. DD1547 with Fields Required for 'Z' Score Calculation Identified by the Filled Blocks

The estimated 3 minutes X 2124 records would result in 106 hours of computer time not including input time. Based on this test a sampling approach was chosen.

The sample size was determined using the 95 percent confidence level standard and a sample size estimating formula provided by Air Force Manpower and Personnel Center. A sample size for a simple random sample was calculated based on a 95 percent confidence level. The computations are shown in below in Equation 1 (11:14).

$$n = \frac{N (z^2) \times p (1 - p)}{(N-1) (d^2) + (z^2) \times p (1 - p)} = 325 \quad (1)$$

where:

n = sample size

N = population size = 2124

p = maximum sample size factor (.5)

d = desired tolerance (.05)

z = factor of assurance ( 1.96) for a 95% confidence level

In order to select a random sample of 325 contracts, a source of random numbers was required. Five hundred random numbers between 1 and 2124 were generated using a MATHCAD template which utilized the MATHCAD random number generator. The number of random numbers generated (500) was increased over what was required by the sample size calculation (325) in Equation 1 in order to allow the elimination of duplicate random numbers. The template is reproduced in Figure 13.

```

ORIGIN = 1
i:= 1..500
Xi = ceil(rnd (2124))
WRITEPRN (rd) := Xi

```

Figure 13. Random Number Template

After the random numbers were generated, they were written to a file (rd), imported into STATISTIX, and sorted into ascending numerical order. Duplicate random numbers were removed resulting in 405 random numbers between 1 and 2124. Eliminating duplicate random numbers was analogous to sampling from a finite population without replacement. Sampling from a finite population without replacement produces a smaller sample standard deviation than sampling with replacement. Based on the sample size calculation in Equation 1, the resultant 405 samples were more than adequate to produce a 95 percent confidence level.

With the random numbers selected, the universe of records had to be sampled. The universe had been reduced to records 220 characters long with commas and quotes between fields. These records were imported into the QUATTRO spreadsheet program (Borland Corporation) using the comma and quote delimiting function to produce a spreadsheet which displayed each record as a row and each field as a column. Each row (record) was sequentially numbered. The sequential number given to the record was called the Contract ID# and identifies the record through the remainder of the analysis. A sample of the standard profit analysis spreadsheet is shown in Figure 14. The spreadsheet was printed in a 240 character

per line format and due to page width restrictions is represent below as three lines per record.

<u>ID#</u>	<u>Contract #</u>	<u>Contractor Name</u>	<u>Type</u>	<u>Effort</u>	<u>Use</u>	<u>Date</u>	<u>SubTotCst</u>	<u>TotCst</u>
1	masked	masked	J	1	2	8810	3114794	3426772

<u>CstFin</u>	<u>L</u>	<u>Fact</u>	<u>IntRt</u>	<u>FC Bldg</u>	<u>FC Eqp</u>	<u>NegTotCst</u>	<u>FC Obj</u>	<u>FC Neg</u>	<u>Prof Neg</u>
856693	.65	9.37	45264	253480	3426772	28290	28290	404938	

<u>KO Name</u>	<u>KO Tel #</u>
masked	masked

Figure 14. Example Spreadsheet for Sample ID #1

Because a sampling approach rather than a census was chosen, a simple random sample of the 2124 records was taken. Based on the 405 random numbers generated by the MATHCAD template and sequentially ordered by STATISTIX, the sample ID #'s corresponding to the 405 unique random numbers were saved and the 1719 records not required for the sample were deleted from the spreadsheet. The resulting spreadsheet contained only the 405 sampled contracts. One of the spreadsheet fields contained all the profits awarded for the defined universe thereby answering the first investigative question.

#### Methodology for Investigative Question # 2

The second investigative question was: For each of the contracts from

Investigative Question #1, what is the population of possible profits (computed using negotiated costs and all combinations of profit factor values permitted by weighted guidelines)? The computation of the population of profits for each contract requires the negotiated costs for each contract, all the applicable profit factor values, and any other limitation cited in the DOD FAR weighted guideline instructions.

Negotiated Costs. The fields from each record that represent populations of negotiated costs required for the 'Z' score calculation were extracted from the universe as was shown in the methodology for Investigative Question 1. These sample spreadsheets were used for Investigative Question #2 with two modifications. Both modifications were to the interest rate field.

The first modification was to adjust all interest rates to be less than 10 percent but greater than 1 percent. Some interest rates appeared in the database as 92.5 percent and others as .925 percent. This was considered an input error and did not effect the validity of the rates. The decimal places were shifted to standardize the interest rate data for ease of later calculation. For example, rates appearing on the sample spreadsheet as 92.5 percent and .925 percent were changed to 9.25 percent.

The second modification involved the omission of interest rate information. Interest rate information is only required on the DD1547 when working capital adjustment is applied. However, the calculation required for this thesis required the interest rate for all records as will be explained later in this section. Because the DOD FAR defines the Interest Rate as the treasury rate at the time of award (1:215.9-

10), the missing interest rates were added based on the applicable treasury rate at the date of award (DD1547 block 4). The rates applicable during FY 89 are shown in Table 3.

Table 3  
Interest Rates Applicable During FY 89 (15:-)

Jul 88 - Dec 88	=	9.25%
Jan 89 - Jun 89	=	9.75%
Jul 89 - Dec 89	=	9.13%

With these two interest rate modifications, the sample spreadsheets were ready for determining negotiated profits.

The range of possible profits was based on the designated range of profit factor values and negotiated costs. The DD1547 was designed to compute an objective profit based on objective costs. Because the form was not designed to compute a negotiated profit, several of the elements necessary to produce a computed negotiated profit are not present. The negotiated costs required but not present are: sub total cost, costs financed, facilities capital employed, and distribution of facilities capital employed.

An estimate of these negotiated cost categories was required in order to re-compute the weighted guidelines using negotiated costs. In each case, a estimate was derived from other data on the DD1547 after making certain assumptions. The negotiated costs required for Investigative Question #2 are either directly available from the Negotiation Summary

Section of each record or they can be derived from the objective costs used by the contracting officer to compute the objective profit. The negotiated costs that were estimated and any necessary assumptions follow.

Estimated Negotiated Sub Total Cost. Assumption #1 for Investigative Question #2 is as follows. Assume the General and Administrative (G&A) rate remains constant between the objective and final negotiated position. This assumption is credible because both the objective and negotiated rate should be based on the Defense Contract Audit Agency (DCAA) recommended rate.

$$\begin{array}{l} \text{Obj SubTot Cst} \\ \text{Neg SubTot Cst} = \frac{(\text{Line 18})}{\text{Obj Tot Cst}} * \text{Neg Tot Cst} \quad (2) \\ \quad \quad \quad (\text{Line 20}) \end{array}$$

Negotiated Costs Financed. Assumption #2 for Investigative Question #2 is as follows. Assume Cost Financed increased/decreased the same percentage as total costs increased/decreased. This assumption is credible because contractors will normally finance the maximum amount allowed by the progress payment clause.

$$\begin{array}{l} \text{Neg Tot Cst} \\ \text{Neg Cst Financed} = \frac{(\text{Line 31})}{\text{Obj Tot Cst}} * \text{Obj Cst Financed} \quad (3) \\ \quad \quad \quad (\text{Line 20}) \end{array}$$

Contractor Facilities Capital Employed. The treasury rate applicable to costs financed is the same as the treasury rate applicable to facilities capital employed (1:230.7003(c)). Using this rule, Objective Facilities Capital Employed can be derived from Objective Facilities Capital Cost of Money and Negotiated Facilities Capital Employed can be derived from Negotiated Facilities Cost of Money.

$$\begin{aligned} & \text{Obj Fac Cap Cost of Money} \\ \text{Obj Fac Cap Empl} = & \frac{\text{(Line 32)}}{\text{Treasury Rt}} & (4) \\ & \text{(Line 26)} \end{aligned}$$

$$\begin{aligned} & \text{Neg Fac Cap Cost of Money} \\ \text{Neg Fac Cap Emp} = & \frac{\text{(Line 32)}}{\text{Treasury Rate}} & (5) \\ & \text{(Line 26)} \end{aligned}$$

Distribution of Facilities Capital Employed. Assumption #3 for Investigative Question # 2 follows. Assume that the negotiated amount for facilities capital employed is distributed in the same percentage manner as the objective facilities capital employed. Specifically, assume the ratio of Objective Facilities Capital Employed for Buildings



to the Total Objective Facilities Capital Employed is the same as the ratio of Negotiated Facilities Capital Employed for Buildings to the Total Negotiated Facilities Capital Employed. The same assumption is applied to Facilities Capital Employed for Equipment. This distribution is determined by DCAA and should not change as a result of negotiation.

$$\begin{aligned} & \text{Obj Fac Cap Emp Bldg} \\ \text{Neg Fac Cap Emp Bldg} = & \frac{\text{(Line 28)}}{\text{Obj Fac Cap Emp}} * \text{Neg Fac Cap Emp} & (6) \\ & \text{(Assumption 3)} \end{aligned}$$

$$\begin{aligned} & \text{Obj Fac Cap Emp Eqp} \\ \text{Neg Fac Cap Emp Eqp} = & \frac{\text{(Line 29)}}{\text{Obj Fac Cap Emp}} * \text{Neg Fac Cap Emp} & (7) \\ & \text{(Assumption 3)} \end{aligned}$$

Section I of the 'Z' score MATHCAD template is used to extract the negotiated costs for each record from the spreadsheet as well as the objective costs necessary to estimate negotiated costs. Section I of the template also performs the calculations to estimate the negotiated costs. Section I of the MATHCAD template using the data from sample ID #1 is presented as Figure 15.

## SECTION I NEGOTIATED COSTS

This sub-section I(a) lists the negotiated costs from the DD1547 and the pertinent data required to estimate those negotiated costs not reported on the DD1547. The field references are a mechanism used to expedite the importing of each sample from the Quattro Spreadsheet into this Mathcad template.

ORIGIN = 1		
s := READPRN(sd)	field := s <sup>T</sup>	
Field Ref. from Sprdsht	Value of Variable	Weighted Guideline Ref
SampleNumber := field <sub>1</sub>	SampleNumber = 1	
ObjSubTotCst := field <sub>2</sub>	ObjSubTotCst = 3114794	(Line 18 of DD1547)
ObjTotCst := field <sub>3</sub>	ObjTotCst = 3426772	(Line 20 of DD1547)
ObjCstFin := field <sub>4</sub>	ObjCstFin = 856693	(Line 26 of DD1547)
LengthFact := field <sub>5</sub>	LengthFact = 0.65	(Line 26 of DD1547)
TreasuryRt := field <sub>6</sub>	TreasuryRt = 0.0937	(Line 26 of DD1547)
ObjFaCapEmpBldg := field <sub>7</sub>	ObjFaCapEmpBldg = 45264	(Line 28 of DD1547)
ObjFaCapEmpEqp := field <sub>8</sub>	ObjFaCapEmpEqp = 253480	(Line 29 of DD1547)
NegTotCst := field <sub>9</sub>	NegTotCst = 3426772	(Line 31 of DD1547)
ObjFaCapCOM := field <sub>10</sub>	ObjFaCapCOM = 28290	(Line 32 of DD1547)
NegFaCapCOM := field <sub>11</sub>	NegFaCapCOM = 28290	(Line 32 of DD1547)
CONegProfit := field <sub>12</sub>	CONegProfit = 404938	(Line 33 of DD1547)

Figure 15. Section I of MATHCAD Template

This sub-section I(b) contains computations to estimate negotiated not reported on the DD1547. For further explanation of each assumption see methodology for Investigative Question #2.

Estimated Negotiated Sub Total Cost 'ASSUMPTION #1 for IV #2'

$$\text{NegSubTotCst} := \left[ \frac{\text{ObjSubTotCst}}{\text{ObjTotCst}} \right] \cdot \text{NegTotCst} \quad \text{NegSubTotCst} = 3114794$$

Estimated Negotiated Costs Financed 'ASSUMPTION #2 for IV #2'

$$\text{NegCstFin} := \left[ \frac{\text{NegTotCst}}{\text{ObjTotCst}} \right] \cdot \text{ObjCstFin} \quad \text{NegCstFin} = 856893$$

Estimated Contractor Facilities Capital Employed

$$\text{ObjFaCapEmp} := \frac{\text{ObjFaCapCOM}}{\text{TreasuryRt}} \quad \text{ObjFaCapEmp} = 301921.0245$$

$$\text{NegFaCapEmp} := \frac{\text{NegFaCapCOM}}{\text{TreasuryRt}} \quad \text{NegFaCapEmp} = 301921.0245$$

Estimated Distribution of Facilities Capital Employed 'ASSUMPTION #3 for IV #2'

$$\text{NegFaCapEmpBldg} := \left[ \frac{\text{ObjFaCapEmpBldg}}{\text{ObjFaCapEmp}} \right] \cdot \text{NegFaCapEmp} \quad \text{NegFaCapEmpBldg} = 45264$$

$$\text{NegFaCapEmpEqp} := \left[ \frac{\text{ObjFaCapEmpEqp}}{\text{ObjFaCapEmp}} \right] \cdot \text{NegFaCapEmp} \quad \text{NegFaCapEmpEqp} = 253480$$

Figure 15. Section I of MATHCAD Template continued

Profit Factors. In order to compute the population of profits for each contract both negotiated costs and the applicable profit factor values are required. The negotiated costs were obtained in the previous section. This section will document the applicable profit factor values.

The applicable profit factor values are given in the weighted guideline instructions. Contracts have different profit factor values depending on the analysis method used (use code) and contract type, and contract financing. The profit factor values applicable to the universe of records used in this research are shown in Table 4.

The applicable profit factor are listed for each analysis method and contract type in Section II of the MATHCAD template. The profit factor values used for a Firm Fixed Price Contract with Progress Payments using the Standard Weighted Guidelines Analysis Method is shown in Figure 16.

Population of Profits. Given the negotiated costs and the applicable profit factors for each contract (Table 4), a population of profits representing the weighted guideline possible profits was calculated.

Section III of the MATHCAD template, Figure 17 shows the computations for the population of profits using the sample ID #1 data from MATHCAD template Sections I and II. Due to space limitations, the profits are not printed in the template. Instead, each possible profit is summed. The sum and the sum of squares is later used in MATHCAD template Section IV to produce the individual contract profit population parameters  $\mu$  (mean) and  $\sigma$  (standard deviation) for the 'Z' score computation.

Table 4

## Profit Factor Values for Reported Contracts Broken Out by Use Code

Use Code 1 ( Alternate Performance Risk )

Use Code 2 ( Standard Facilities Capital Employed )

Use Code 3 ( Alternate Facilities Capital Employed )

USE CODE	CONTRACT TYPE/CODE	* ACTIONS	PERFORMANCE RISK	CONTRACT TYPE RISK	FAC. CAPITAL		FAC. CAPITAL	
					EMP.	BUILDING	EMP.	EQUIPMENT
1	FPI /L*	3	4-6-8	0-1-2	N/A		N/A	
	FFP /J	47	4-6-8	4-5-6	N/A		N/A	
	FFP /J*	44	4-6-8	2-3-4	N/A		N/A	
	CPAF/R	8	N/A	N/A	N/A		N/A	
	CPFF/U	212	4-6-8	0-.5-1	N/A		N/A	
	CPIF/V	5	4-6-8	0-1-2	N/A		N/A	
		319						
2	FPR /A*	1	2-4-6	0-1-2	10-15-20		20-35-50	
	FPI /L	7	2-4-6	2-3-4	10-15-20		20-35-50	
	FPI /L*	102	2-4-6	0-1-2	10-15-20		20-35-50	
	FFP /J	218	2-4-6	4-5-6	10-15-20		20-35-50	
	FFP /J*	1021	2-4-6	2-3-4	10-15-20		20-35-50	
	FPE /K	1	2-4-6	2-3-4	10-15-20		20-35-50	
	FPE /K*	3	2-4-6	0-1-2	10-15-20		20-35-50	
	CPAF/R	3	N/A	N/A	N/A		N/A	
	CPFF/U	291	2-4-6	0-.5-1	10-15-20		20-35-50	
	CPIF/V	38	2-4-6	0-1-2	10-15-20		20-35-50	
		1685						
3	FPI /L*	1	2-4-6	0-1-2	0-5-10		15-20-25	
	FFP /J	11	2-4-6	4-5-6	0-5-10		15-20-25	
	FFP /J*	16	2-4-6	2-3-4	0-5-10		15-20-25	
	FPE /K	2	2-4-6	2-3-4	0-5-10		15-20-25	
	FPE /K*	2	2-4-6	0-1-2	0-5-10		15-20-25	
	CPFF/U	82	4-6-8	0-.5-1	0-5-10		15-20-25	
	CPIF/V	6	4-6-8	0-1-2	0-5-10		15-20-25	
		120						

\* Contracts which included progress payments. Working capital adjustment for these contracts was limited to 4% of total cost.

## SECTION II PROFIT FACTORS

This section lists the DOD Profit Factors

$$\text{PerfVal} := \begin{bmatrix} .02 \\ .03 \\ .04 \\ .05 \\ .06 \end{bmatrix} \quad \text{CtrTypVal} := \begin{bmatrix} .02 \\ .03 \\ .04 \end{bmatrix} \quad \text{FaCapBldgVal} :=$$

$\begin{bmatrix} .1 \\ .11 \\ .12 \\ .13 \\ .14 \\ .15 \\ .16 \\ .17 \\ .18 \\ .19 \\ .2 \end{bmatrix}$

$$\text{FaCapEqpVal} :=$$

$\begin{bmatrix} .2 \\ .21 \\ .22 \\ .23 \\ .24 \\ .25 \\ .26 \\ .27 \\ .28 \\ .29 \\ .30 \\ .31 \\ .32 \\ .33 \\ .34 \\ .35 \\ .36 \\ .37 \\ .38 \\ .39 \\ .40 \\ .41 \\ .42 \\ .43 \\ .44 \\ .45 \\ .46 \\ .47 \\ .48 \\ .49 \\ .50 \end{bmatrix}$

Figure 16. Section II of MATHCAD Template

### SECTION III PROFIT COMPUTATION

This sub-section III(a) recomputes weighted guidelines using negotiated costs and all possible combinations of the profit factors. It in effect generates the population of N possible profits for this sampled contract.\*

```
ProfPerfRsk := PerfVal·NegSubTotCst  
ProfCtrTypRsk := CtrTypVal·NegSubTotCst  
ProfFaCapEmpBldg := FaCapBldgVal·NegFaCapEmpBldg  
ProfFaCapEmpEqp := FaCapEqpVal·NegFaCapEmpEqp
```

This sub-section III(b) computes the working capital adjustment and limits it to 4% of total cost.

```
OptionA := NegCstFin·LengthFact·TreasuryRt    OptionB := .04·NegTotCst  
ProfCstFin := if(OptionA < OptionB,OptionA,OptionB)
```

Figure 17. Section III of the MATHCAD Template

This sub-section III(c) lists the criteria for the N combinations of profit factors.

```
n1 := 5      n2 := 3      n3 := 11      n4 := 31
i := 1..n1   j := 1..n2   k := 1..n3     l := 1..n4
```

```
a := ProfPerfRak
b := ProfCtrTypRak
c := ProfFaCapEmpBldg
d := ProfFaCapEmpEqp
e := ProfCstFin
```

In this sub-section III(d), rather than list each of the N possible profits, the template sums the N possible profits (SUM), and generates a sum of squares (SSQ) which will be used in the next section to calculate population parameters.

```
SUMl := 0      SSQl := 0      N := n1.n2.n3.n4      N = 5115
```

```
SUMl := SUMi + ai + bj + ck + dl + e
```

```
SUMl      μ :=  $\frac{\text{SUM}_l}{N}$ 
```

```
SSQl :=  $\left[ \left[ a_i + b_j + c_k + d_l + e \right]^2 - \mu^2 \right] + \text{SSQ}_l$ 
```

Figure 17. Section III of MATHCAD Template continued



### Methodology for Investigative Question #3

The third investigative question is: What is the "Z" score for each contract following the "Actual Process" based on the negotiated profit from Investigative Question #1 and the population of all possible profits from Investigative Question #2 ?

A "Z" score is a measure of the number of standard deviations a particular negotiated profit is from the mean of all possible profits given that the distribution of all possible profits is normal. The following example will demonstrate that the population of all possible profits is normally distributed and that the mean equals the sum of the normal profit factor values. In the Table 5 example there are 3 choices for performance risk, 3 choices for contract type risk, 3 choices for facilities capital (buildings), and 5 choices for facilities capital(equipment). The total number of combinations is represented by N and equals the product of the number of choices at each step. From Table 5,  $N = 3 \times 3 \times 3 \times 5 = 135$  possible combinations of profit (4:46). The median profit factor value is identified by DFAR as the normal value. The normal profit factor value is the value assigned where average conditions exist when compared to all goods and services purchased by DOD.

The MATHCAD template shown in Figure 18 computes all the possible profits and displays the mean profit, the median profit, and the sum of the normal profit factor values. Note that all of the results are equal. The MATHCAD template also writes the entire population of profits to a file called (thy). The contents of the file are read into STATISTIX and used to create the frequency distribution shown in Figure 19.

Table 5

Profit Factor Values Used in Example

<u>Performance Risk</u>	<u>Contract Type Risk</u>	<u>Fac Cap Bldg</u>	<u>Fac Cap Eqp</u>
2	5	8	11
3 *	6 *	9 *	12
4	7	10	13 *
			14
			15

\* the normal profit factor value

STATISTIX is a statistical software program produced by NH Analytical Software Corporation. Note that the frequency distribution of the allowable weighted guidelines profit factor values results in what appears to be a normal distribution. Confirming the appearance is the Wilk Shapiro normality test.

If the sample conforms to a normal distribution, a plot of the rankits against the order statistics should result in a straight line, except for random variation. Systematic departure of the rankit plot from a linear trend indicates non-normality, as does a small value for the Wilk-Shapiro statistic. The approximate Wilk-Shapiro statistic calculated is the square of the linear correlation between the rankits and the order statistics. (23:8.5)

A Wilk Shapiro statistic greater than .90 is a good indicator of normality.

There are two differences between the simplified description above and the population of profits generated by weighted guidelines. The first difference is that weighted guidelines produce a much larger population of profits. This occurs due to the larger profit factor

# Distribution of Sum of Vector Elements

This template demonstrates the values which result from adding four vectors element by element.

The example vectors are shown below. The first operation will be to add 2+5+8+11= 26 The second operation will be to add 2+5+8+12= 27 etc. until all combinations are used. The total number of combinations = N

N := 3 3 3 3 5 N = 135

Using the following iterative equation, the computer will sum the individual elements of each vector and write the 135 values to a file called (thy).

$$A := \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix} \quad B := \begin{bmatrix} 5 \\ 6 \\ 7 \end{bmatrix} \quad C := \begin{bmatrix} 8 \\ 9 \\ 10 \end{bmatrix} \quad D := \begin{bmatrix} 11 \\ 12 \\ 13 \\ 14 \\ 15 \end{bmatrix}$$

$$i := 1 \dots 3 \quad j := 1 \dots 3 \quad k := 1 \dots 3 \quad l := 1 \dots 5$$

$$\text{SUM}_l := 0 \quad \text{SUM}_l := \text{SUM}_l + A_i + B_j + C_k + D_l$$

$$\text{WRITEPRN}(\text{thy}) := A_i + B_j + C_k + D_l$$

$$P := \text{READPRN}(\text{thy})$$

$$\text{Low Profit}_l \quad P_l = 26 \quad \text{High Profit}_{135} \quad P_{135} = 36 \quad \text{Median Profit}_{68} \quad P_{68} = 31$$

$$\text{Average Profit} \quad \mu := \frac{\text{SUM}_l}{N} \quad \mu = 31$$

Normal Profit (Sum of normal profit factor values)

$$NP := A_2 + B_2 + C_2 + D_3 \quad NP = 31$$

Figure 18. MATHCAD Template Generating Population of Profits for Example

# FREQUENCY DISTRIBUTION OF THEORY

VALUE	N
26	1 *
27	4 ****
28	10 *****
29	17 *****
30	23 *****
31	25 *****
32	23 *****
33	17 *****
34	10 *****
35	4 ****
36	1 *

NON-MISSING 135  
MISSING 0  
TOTAL 135

## DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
THEORY	31.00	2.007	135	31.00	26.00	36.00

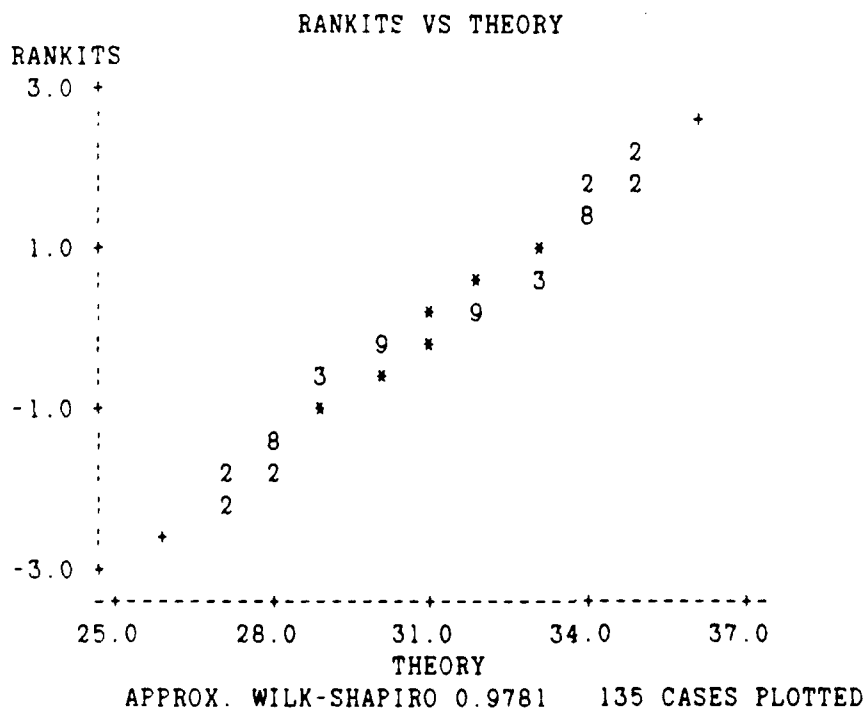


Figure 19. Parameters and Normality Test for Example Population

value ranges. As the profit factor values are carried beyond one decimal place, the density of the frequency distribution increases but the high and low values remain the same. For the purpose of this thesis, the computed range of possible profits will use whole number profit factor values. This discrete distribution resulting from whole number profit factor values was used to approximate the continuous distribution which would have been created by carrying the profit factor values to an infinite number of decimal places. Whole numbers will provide sufficient detail to allow the computation of a standard deviation and the assumption of a normal distribution.

The second distinction between the simplified example and the computation in the weighted guidelines is that profit factor values are multiplied by different negotiated costs. This changes the central tendency and the variance of the profit population distribution but the shape will continue to follow the normal distribution. From the Table 5 example, the possible profits for any weighted guidelines application will form a normal distribution with the mean equal to the product of weighted guideline normal profit values and negotiated costs.

The Table 5 example demonstrated theoretically that the possible profits using all combinations of profit factor values were normally distributed. To empirically show this, Section IV of the MATHCAD template was created and is shown in Figure 20. Section IV of the template uses the sample ID #1 data from MATHCAD Sections I, II, and III to compute the population of possible profits, and to display the mean profit, the median profit, and the sum of the normal profit factor

# SECTION IV PROFIT DISTRIBUTION

This section writes all possible negotiated profits to a file J1.prn. It also demonstrates that the mean equals the median which equals the sum of the normal profit factor values and their associated negotiated costs.

N := n1 n2 n3 n4

N = 5115

SUM<sub>1</sub> := 0 SUM<sub>1</sub> := SUM<sub>1</sub> + a<sub>1</sub> + b<sub>j</sub> + c<sub>k</sub> + d<sub>l</sub> + e

WRITEPRN(pf) := a<sub>1</sub> + b<sub>j</sub> + c<sub>k</sub> + d<sub>l</sub> + e

P := READPRN(pf)

Low Profit P<sub>1</sub> = 232000 High Profit P<sub>5115</sub> = 499400

Median Profit P<sub>2558</sub> = 365700

Average Profit  $\mu := \frac{\text{SUM}_1}{N}$   $\mu = 365720.0672$

Normal Profit (Sum of normal profit factor values X negotiated costs)

NP := a<sub>3</sub> + b<sub>2</sub> + c<sub>6</sub> + d<sub>16</sub> + e NP = 365720.0672

Figure 20. Section IV of MATHCAD Template

values. Note that all of these results were equal. The template also wrote the entire population of profits to a file called (pf).

The contents of file (pf) were written to a file and imported into STATISTIX in order to plot a frequency distribution of the 5115 possible profits. The result shown in Figure 21 shows the relative frequency of each profit outcome, and the parameters associated with the population of profits. Note that the frequency distribution of the population of profits appears to be normally distributed. The Wilk Shapiro normality statistic of .99 confirms the appearance. The empirical test of sample ID #1 demonstrated that the population of profits was normally distributed. Given the normal distribution, the 'Z' statistic was appropriate to measure the number of standard deviations that each negotiated profit was from the mean of all possible profits.

The 'Z' score for each contract was computed based on the negotiated profit resulting from Investigative Question # 1 and the mean ( $\mu$ ) and standard deviation ( $\sigma$ ) from Investigative Question # 2. The 'Z' score was computed using Equation 8.

$$Z = \frac{X - \mu}{\sigma} \quad (8)$$

where:

X = negotiated profit

$\mu$  = mean of each profit distribution

$\sigma$  = standard deviation of each distribution

# HISTOGRAM OF ACTUALPRO

LOW	HIGH	(X 10 <sup>-5</sup> )	N
2.320	2.720	*****	237
2.720	3.120	*****	736
3.120	3.520	*****	1123
3.520	3.920	*****	1279
3.920	4.320	*****	1091
4.320	4.720	*****	533
4.720	5.120	****	115

CASES INCLUDED 5114 MISSING CASES 0

## DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
ACTUALPRO	3.657E+05	5.571E+04	5115	3.657E+05	2.320E+05	4.994E+05

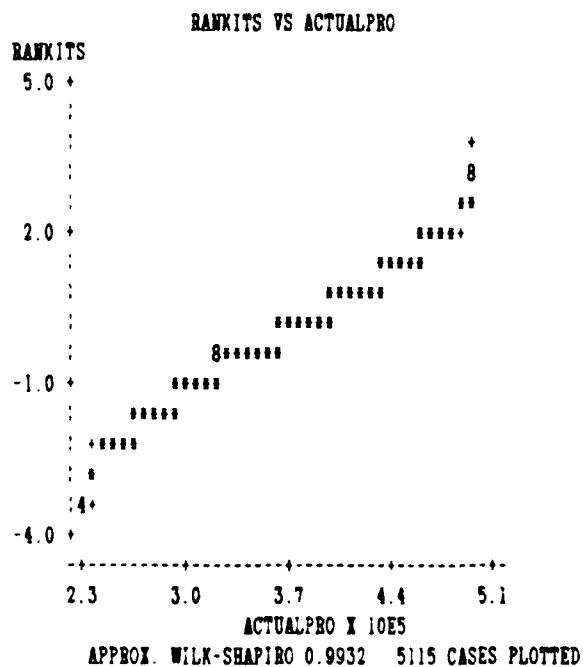


Figure 21. Parameters and Normality Test for Sample ID #1



Section IV of the MATHCAD was modified from its previous use in Figure 20 in order to compute  $\mu$  and  $\sigma$  for each weighted guidelines record, and to report the 'Z' score using Equation 8. The revised MATHCAD Section IV used the sample ID #1 data from MATHCAD sections I, II, and III. MATHCAD Section IV is shown in Figure 22. The template was run for each of the 405 samples to answer Investigative Question #3.

#### Methodology for Hypothesis Test

The hypothesis states: The average 'Z' score for contract profits when considering all goods and services acquired by DOD following the 'Actual Process' ( $\mu_A$ ) equals the average 'Z' score for the 'Theoretical Process' ( $\mu_T$ ).

The 'Theoretical Process' population parameter  $\mu_T$  is known to equal zero. If a census of the 'Actual Process' had been conducted, this comparison of the 'Actual and Theoretical Processes' could have been made by comparing the 'Actual Process' population parameter  $\mu_A$  to the 'Theoretical Process' population parameter  $\mu_T$ . Any difference between the two population means based on the assumptions of this thesis would be attributable to the net effect of the 'Other Variables'.

Because a sample was drawn from the 'Actual Process', the parameter  $\mu_A$  was not known. Instead, the 'Actual Process' was represented by the statistic  $\bar{z}$ . The statistic  $\bar{z}$  is the sum of all 'Z' scores from Investigative Question #3 divided by the number of 'Z' scores. A statistical hypothesis test was used to show if the 'Actual Process' as represented by  $\bar{z}$  is significantly different than the mean of the 'Theoretical Process' ( $\mu_T$ ). A description of the sampling distribution of  $\bar{z}$  and the steps for the hypothesis test follow.

#### SECTION IV 'Z' SCORE COMPUTATION

This section calculates the parameters necessary to compute a 'Z' score. See methodology for justification for 'Z' distribution.

$$\sigma := \sqrt{\frac{SSQ}{N}} \quad \sigma = 55706.8232 \quad \mu := \frac{\text{SUM}}{N} \quad \mu = 365720.0672$$

X := CONegProfit

$$ZSCORE := \frac{X - \mu}{\sigma} \quad ZSCORE = 0.7$$

Figure 22. Section IV of MATHCAD Template for 'Z' Score

Sampling Distribution of ZBAR. The sample consisted of  $n = 405$

profit 'Z' scores. The sample had its own distribution with some measure of central tendency and some measure of dispersion. The measure of central tendency is the sample mean and is referred to as  $\bar{z}$ . The measure of dispersion is the sample standard deviation and is referred to as  $s$ . If another sample of size 405 was taken, the sample mean could have been different. The sample means ( $\bar{z}$ s) are distributed in accordance with the sampling distribution of  $\bar{z}$ . The sampling distribution of  $\bar{z}$  is the probability distribution of all possible values of  $\bar{z}$  that could occur when a sample size of 405 is taken from the parent population of size  $N = 2124$ . By the Central Limit Theorem, the distribution of the means of the random samples will approach a normal distribution with mean ( $\mu_A$ ) and variance ( $\sigma^2/n$ ) as the sample size  $n$  approaches infinity.

The standard deviation of the population of values ( $\sigma$ ) is not known but due to the large size of the sample, the sample standard deviation  $s$  is approximately equal to the population standard deviation ( $\sigma$ ) (12:163). The variance of the sampling distribution of  $\bar{z}$  was then estimated as  $s^2/n$ . The square root of the formula is also known as the standard error of the mean ( $\sigma_{\bar{z}}$ ). The variance of the sampling distribution was adjusted by a Finite Population Correction Factor to account for sampling from the finite population without replacement (10:372). This correction factor is shown in Equation 8.

$$\sigma_{\bar{z}} = (s/\sqrt{n}) \sqrt{(N-n)/N-1} \quad (8)$$

A hypothetical sampling distribution of  $\bar{z}$  is shown in Figure 23.

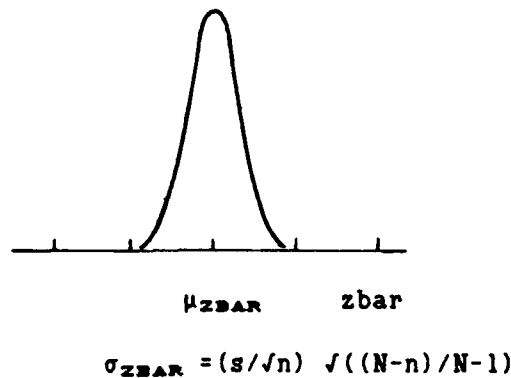


Figure 23. Hypothetical Sampling Distribution of  $\bar{z}$

The hypothetical sampling distribution demonstrates that the sample mean ( $\bar{z}$ ) may not equal the mean of the sampling distribution ( $\mu_{\bar{Z}}$ ) although the mean of the sampling distribution  $\mu_{\bar{Z}}$  will always equal the population mean  $\mu_A$  (10:267). A hypothesis test was conducted to determine if the mean of the sampling distribution ( $\mu_{\bar{Z}}$ ) equaled the 'Theoretical Process' mean ( $\mu_T$ ). If the sample mean ( $\bar{z}$ ) was significantly different from the population mean ( $\mu_T$ ) then it could be assumed that  $\mu_{\bar{Z}}$  and hence  $\mu_A$  do not equal  $\mu_T$ .

Steps to Test the Hypothesis. The hypothesis test was conducted using the following five steps:

1. State the Null and Alternative Hypothesis
2. Determine the Appropriate Test Statistic
3. Determine the Critical Regions
4. Compute the Value of the Test Statistic
5. Make the Statistical Decision

State the Null and Alternative Hypothesis. The hypothesis was:

The average 'Z' score for contract profits, when considering all goods and services acquired by DOD, following the 'Actual Process' equals the average 'Z' score for the 'Theoretical Process'. The hypothesis test intended to show that even if the sample mean for the 'Actual Process' ( $\bar{z}$ ) did not equal zero, the mean of the sampling distribution could still be zero. If the mean of the sampling distribution equaled zero, the knowledge claim could be made that there is no significant difference between the 'Actual Process' and the 'Theoretical Process' hence the 'Other Variables' have no net effect on 'Steps 3 and 4' of the Defense Profit Process. A two sided test was conducted because it could not be ruled out that the true value for the mean of the population of profit 'Z' scores may lie on either side of zero. The purpose of the hypothesis test was not to determine the true value of  $\mu_A$  but only to determine if  $\mu_A$  equaled  $\mu_T$ .

Null Hypothesis :  $H_0 : \mu_A = \mu_T$  The null hypothesis value claim is that the 'Actual Process' and the 'Theoretical Process' yield the same results. The null hypothesis knowledge claim is that the 'Other Variables' have no net effect on 'Steps 2 and 3' of the Defense Profit Process.

Alternate Hypothesis :  $H_A : \mu_A \neq \mu_T$  The alternate hypothesis value claim is that the 'Actual Process' and the 'Theoretical Process' yield different results. The alternate hypothesis knowledge claim is that the 'Other Variables' have a net effect on 'Steps 2 and 3' of the Defense Profit Process.

Determine the Appropriate Test Statistic. A valid test statistic must satisfy three conditions (10:352).

1. Its probability function must be known when it is assumed that the null hypothesis is true.
2. It must contain the parameter being tested.
3. All of its remaining terms must be known or calculable from the sample.

A 'zee' statistic was used. The transformation formula for the 'zee' statistic is shown in Equation 9.

$$\text{'zee'} = \frac{\text{zbar} - \mu}{(s/\sqrt{n}) \sqrt{((N-n)/(N-1))}} \quad (9)$$

where:

zbar = sample mean  
 $\mu = \mu_T = 0$   
s = sample standard deviation  
N = population size  
n = sample size

A 'zee' statistic is the same basic formula as a 'Z' statistic but 'zee' was used as the statistic for the hypothesis test to avoid confusion with the 'Z' score used to measure the individual contract profits. A 'zee' statistic meets the three criteria for a valid test statistic.

1. The distribution of 'zee' is  $N(0,1)$
2. It contains the parameter  $\mu$ .
3. The remaining terms s, n, and zbar were available from the sample.

Determine the Critical Regions. The critical region is composed of the values of the test statistic 'zee' which will cause the null hypothesis to be rejected. The size of the critical region is controlled by the value of  $\alpha$  also known as the level of significance. This research used an  $\alpha = .05$  level of significance. This represents no more than a five percent chance of rejecting the null hypothesis when it is true (Type 1 Error). When  $\alpha = .05$ , the values of 'zee<sub>CRITICAL</sub>' that cut off  $\alpha/2 = .025$  in each tail of the standardized normal distribution are  $\pm 1.96$  standard deviations from the mean. The critical regions are shown in Figure 24.

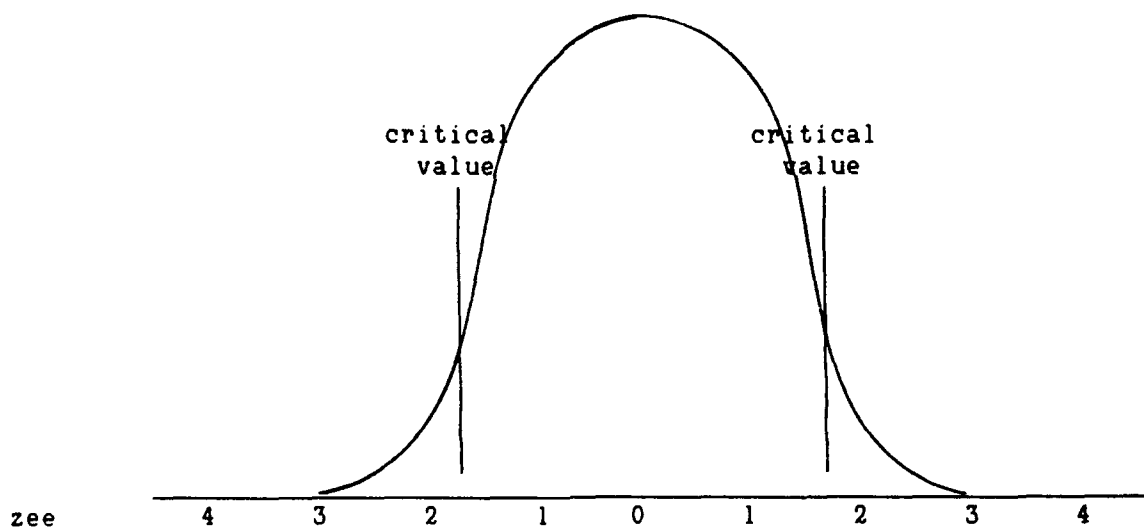


Figure 24. Critical Regions for Hypothesis Test

Compute the Value of the Test Statistic. The value of 'zee' calculated on the basis of the sample is called a computed 'Z' value and is denoted by 'zee<sub>COMPUTED</sub>' as shown in Equation 10 .

$$z_{\text{computed}} = \frac{\bar{z} - \mu}{(s/\sqrt{n}) \sqrt{(N-n)/(N-1)}} \quad (10)$$

where:

$\bar{z}$  = sample mean  
 $\mu = \mu_T = 0$   
 $s$  = sample standard deviation  
 $N$  = population size  
 $n$  = sample size

Make the Statistical Decision. If the calculated value of the test statistic falls in the critical region, then  $H_0$  is rejected. When the calculated value lies in the acceptance region, then  $H_0$  is accepted (10:359).



#### IV. Findings and Analysis

##### Introduction

The results of sampling the universe of contracts and the subsequent hypothesis test are reported in this chapter. The results for Investigative Questions 1 through 3 are not published per the agreement with the database managers however the results are summarized by the sample statistic  $\bar{z}$ . Following the results of the hypothesis test, other significant findings are reported.

##### Results of Sampling

The sample contained  $n = 405$  profit 'Z' scores from the population of  $N = 2124$  profit 'Z' scores. The results of the sample are plotted as a frequency distribution in Figure 25 along with the sample statistics and the results of the Wilk Shapiro normality test.

Note that the sample mean,  $\bar{z}$ , equals .2440 which is above the expected value of zero. A hypothesis test was conducted to determine if the sample mean,  $\bar{z}$ , (representing the 'Actual Process') was significantly different than the population mean ( $\mu_T$ ) (representing the 'Theoretical Process').

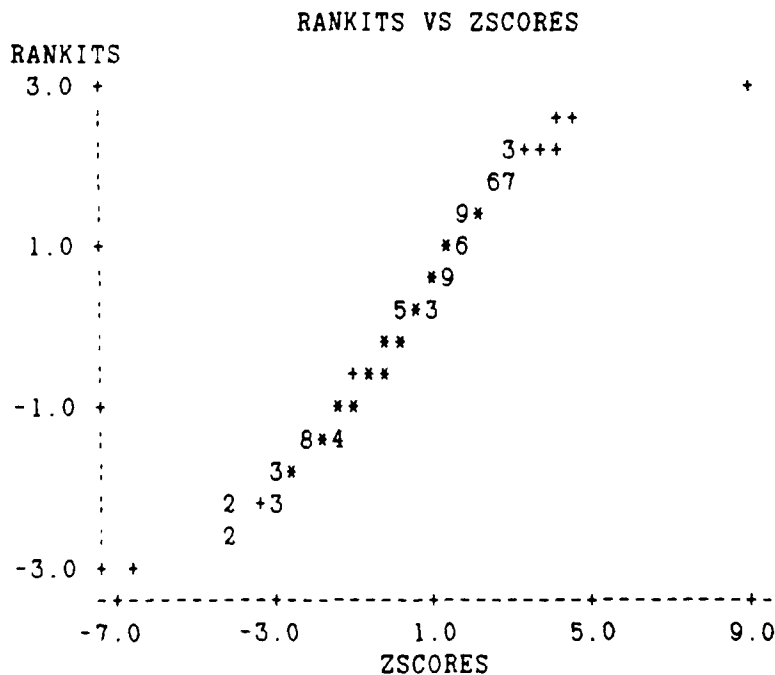
# FREQUENCY DISTRIBUTION OF ZSCORES

VALUE	N
-6	1 ;
-4	4 ;*
-3	5 ;*
-2	21 ;****
-1	47 ;*****
0	215 ;*****
1	74 ;*****
2	29 ;*****
3	5 ;*
4	3 ;*
8	1 ;

NON-MISSING	405
MISSING	0
TOTAL	405

## DESCRIPTIVE STATISTICS

VARIABLE	MEAN	S.D.	N	MEDIAN	MINIMUM	MAXIMUM
ZSCORES	2.440E-01	1.534	405	3.600E-01	-6.420	8.940



APPROX. WILK-SHAPIRO 0.9617 405 CASES PLOTTED

Figure 25. Sample Distribution of Contract Profit 'Z' Scores

## Hypothesis Test

The five steps of the hypothesis test are performed below.

### State the Null and Alternative Hypotheses.

Null Hypothesis :  $H_0 : \mu_A = \mu_T$  The null hypothesis value claim is that the 'Actual Process' and the 'Theoretical Process' yield the same results. The null hypothesis knowledge claim is that the 'Other Variables' have no net effect on 'Steps 2 and 3' of the Defense Profit Process.

Alternate Hypothesis :  $H_A : \mu_A \neq \mu_T$  The alternate hypothesis value claim is that the 'Actual Process' and the 'Theoretical Process' yield different results. The alternate hypothesis knowledge claim is that the 'Other Variables' have a net effect on 'Steps 2 and 3' of the Defense Profit Process.

Determine the Appropriate Test Statistic. The 'zee' statistic as defined in Equation 9 was used as the test statistic.

Determine the Critical Region. When the level of significance ( $\alpha$ ) = .05, the value of  $zee_{CRITICAL}$  that cuts off  $\alpha/2 = .025$  in each tail of the standardized normal distribution is  $\pm 1.96$  standard deviations from the mean.

Compute the Value of the Test Statistic. A 'zee' statistic was used. The transformation for the 'zee' statistic based on the sample data is shown in Equation 11.

$$z_{\text{COMPUTED}} = \frac{\bar{z} - \mu}{(s/\sqrt{n}) \sqrt{(N-n)/(N-1)}} \quad (11)$$

where:

$$\begin{aligned} \bar{z} &= .2440 \\ \mu &= \mu_T = 0 \\ N &= 2124 \\ n &= 405 \\ s &= 1.534 \end{aligned}$$

$$z_{\text{COMPUTED}} = \frac{.2440 - 0}{(1.534/\sqrt{405}) \sqrt{(2124 - 405)/(2124 - 1)}}$$

$$z_{\text{COMPUTED}} = 3.55$$

Make the Statistical Decision. The 'zee' statistic is in the critical region, as shown in Figure 26 below; reject the null hypothesis.

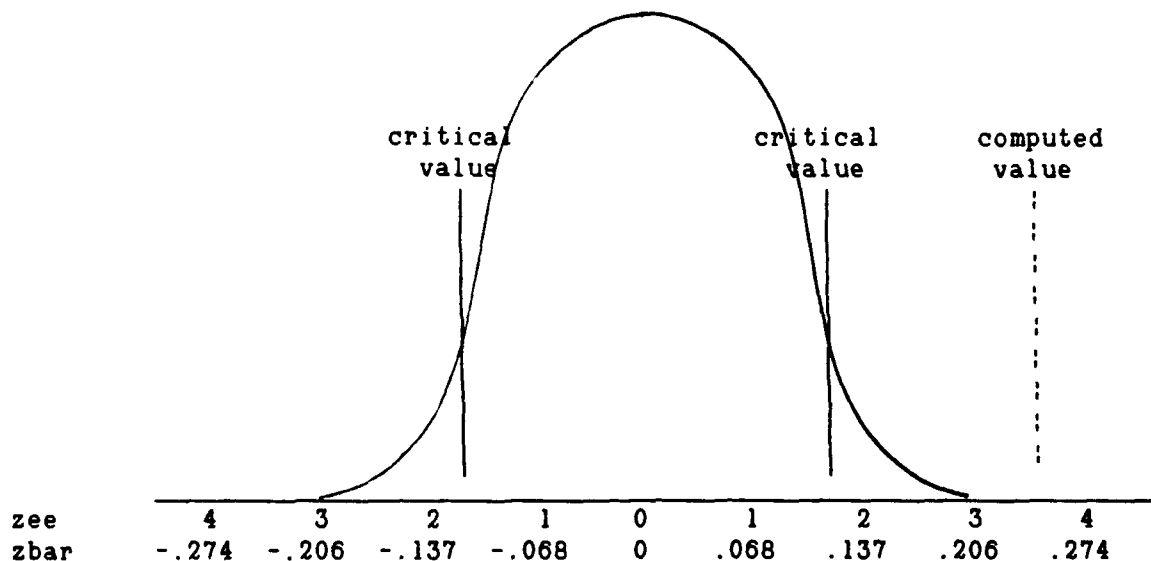


Figure 26. Hypothesis Test on Sampling Distribution

### Other Significant Findings

In the process of investigating ways to measure the "Theoretical and Actual Processes", it was discovered that the population of possible profits resulting from all combinations of profit factor values was normally distributed. It was also discovered that the "Z" scores of reported negotiated profits are also normally distributed. The significance of these two findings is discussed below.

The Population of Possible Profits Generated by Weighted Guidelines are Normally Distributed. The population of possible profits resulting from all combinations of weighted guidelines profit factor values are normally distributed, and the mean of the population (equivalent to the profit computed using the normal profit factor values) is the expected profit when average conditions prevail. Based on the normal distribution, a "Z" score for the negotiated profit provides a measure of how that negotiated profit compares to the profit policy expected value.

Reported Negotiated Profits are Normally Distributed. The normal distribution of reported profits was shown in Figure 25. The normal distribution allows the construction of a process control chart for negotiated profit. In order to construct a process control chart, the individual contract "Z" scores are spread randomly across the horizontal axis. Typically, the horizontal axis represents a time series and each contract could have been plotted relative to the negotiation date (block 4 of DD 1547); however, no correlation between the negotiation date and the profit "Z" score was expected within the one year period therefore this extra step was not taken.

Note that for illustration purposes,  $\bar{z}$ , the sample mean is assumed to equal  $\mu_A$ , the population mean. Also for illustration purposes,  $s$ , the sample standard deviation is assumed to equal  $\sigma$ , the population standard deviation. The parameters  $\mu_A$  and  $\sigma$  could be found by computing 'Z' scores for all 2124 records in the universe but the sample statistics  $s$  and 'Z' are considered adequate for example purposes. Equation 12 shows the computation for the  $3\sigma$  upper and lower control limits.

$$\text{Upper Control Limit} = \mu_A + 3\sigma = 4.8 \quad (12)$$

$$\text{Lower Control Limit} = \mu_A + 3\sigma = -4.4$$

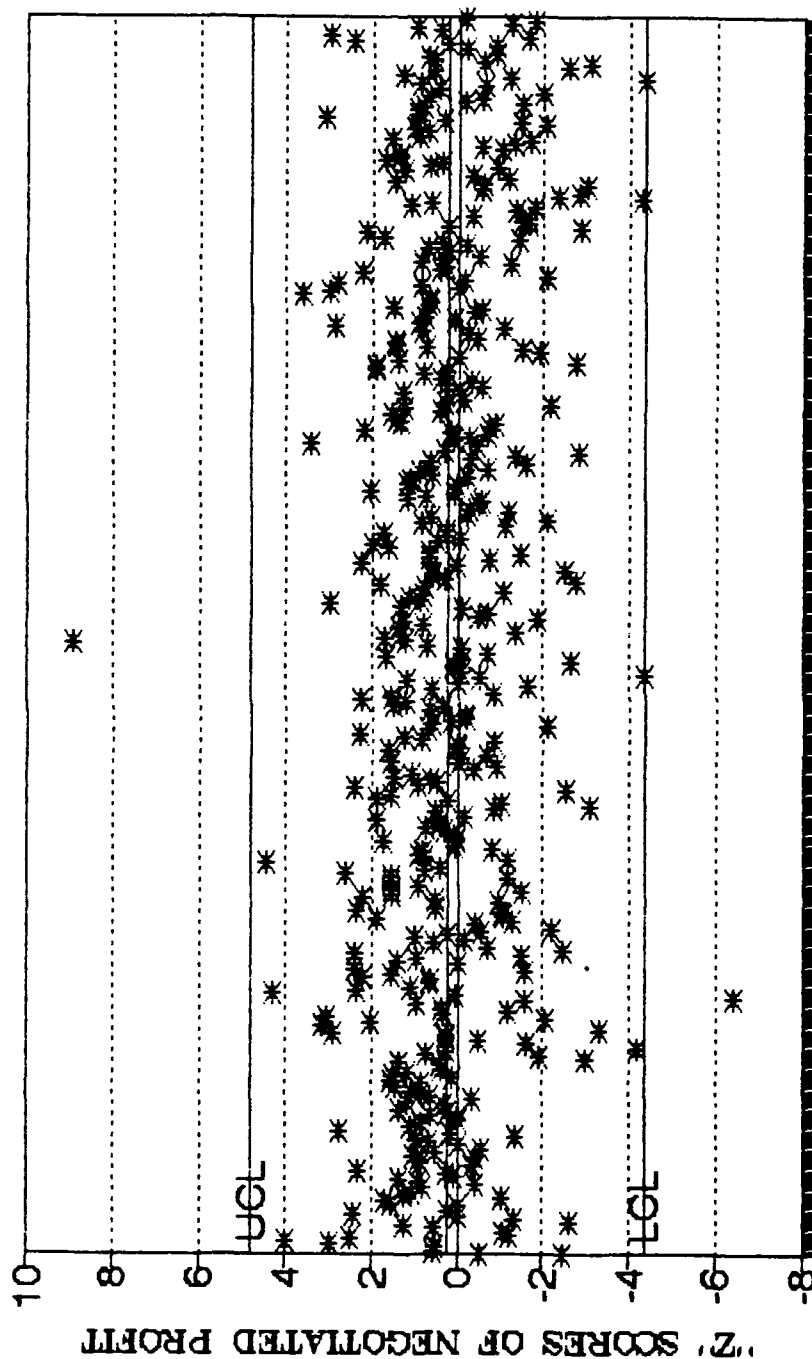
where:

$$\mu = .244 = \text{mean of } \bar{z} \text{ distribution}$$

$$\sigma = 1.534 = \text{standard deviation of } \bar{z} \text{ distribution}$$

The results of the process control chart for the sample of 405 records is shown in Figure 27. The contract profits which fall outside the upper and lower control limits may be a result of some special cause of variation. "Special variation results from some specific faults in the process. Correction of a fault will remove the special variation assignable to that fault. When the process is operating with all special causes of variation eliminated, the process is said to be in a state of statistical control" (20:552). Common variation is a result of the allowable ranges of the weighted guideline profit factor values.

# WEIGHTED GUIDELINES PROCESS CONTROL CHART



FY 1989 NEGOTIATED CONTRACTS

Figure 27. The Weighted Guidelines Process Control Chart

## V. Conclusions and Recommendations

### Introduction

This section will present the practical implications of the results, the policy implications for management, and recommendations for implementation and refinement.

### Practical Implications of the Results

There were three practical implications of the results. The first regards the Defense Profit Process model, the second addresses the results of the hypothesis test, and the third regards the use of the 'Z' score for measuring profits.

The Defense Process Model. The forward to the Department of Defense Annual Profit Report makes the following statement.

Most of the tables relate to the contracting officer's negotiation objective on profit because this is where DOD's profit policy is applied. The profit objective is not equivalent to negotiated profit (Amount included in the contract) or realized profit (amount ultimately earned). It is very important to keep these distinctions in proper perspective. (2:1)

The Defense Profit Model on page 2 and 3 of this thesis displays these distinct steps in the profit process and may help to put the distinctions between the different profit types in perspective.

Hypothesis Test. The hypothesis test based on the average profit 'Z' score validated the Defense Financial and Investment Review Personnel Survey findings that forces other than weighted guidelines have a significant impact on negotiated profit.



Use of 'Z' Score for Measuring Profit. The 'Z' score is used both as a measure of how closely the negotiated profit compares to the expected profit assignment, and to control the weighted guidelines process.

Comparing Negotiated Profit to the Expected Profit Assignment. The 'Z' score can be used to measure the number of standard deviations either the objective profit or the negotiated profit is from the profit which would be obtained using normal values. The current indicator of profit is mark-up rate which measures profit as a percentage of cost. The mark-up rate does not give an indication of how the negotiated profit compares to profit policy.

Controlling the Weighted Guidelines Process. The individual contract 'Z' scores plotted on a control chart would be valuable in controlling special causes of variation. The control limits could be set around the 'Actual Process' mean,  $\mu_A$ , or the control chart could be adapted to use the 'Theoretical Process' mean,  $\mu_T$ . By using the 'Theoretical Process' mean ( $\mu_T = 0$ ) it will no longer be a true process control chart but the contract profits that exceed the control limits would be a good place to start an investigation of why the 'Actual Process' mean does not equal the 'Theoretical Process' mean.

#### Policy Implications for Management

There are two policy implications for management. The first is based on the impact of the 'Other Variables', and the second is a result of the 'Z' score measurement which can be used for both comparing individual negotiated profits to the expected profit and for weighted guidelines process control.

Impact of 'Other Variables'. The result of the hypothesis test showed that for FY89, the actual negotiated profits were higher than expected. If DOD wants profits negotiated that would be in line with the expected results from the current weighted guideline structure, either the 'Other Variables' must be eliminated or the current guideline factors must be reduced to allow for the upward over all influence of the 'Other Variables'.

Use of 'Z' Score for Individual Feedback. The profit 'Z' score would provide contracting officers with immediate feedback on how the 'Z' score of the profit compares to the profit policy expected value. The 'Z' score measurement is preferable to the markup rate because it is based solely on profit policy as applied to the instant contract and it discourages influence by 'Other Variables' such as profits negotiated on previous contracts, and local management direction.

Use of 'Z' Score for Process Control. The individual profit 'Z' scores can be used to produce a process control chart similar to Figure 27. This type of control chart would allow contract managers to look for special causes of variation in the profit process. The control limit would be set either  $3\sigma$  above and below the 'Theoretical Process' mean ( $\mu_T$ ) which by assumption #1 equals zero or  $3\sigma$  above and below the 'Actual Process' mean ( $\mu_A$ ) which would have to be calculated from the data.

## Recommendations

### Recommendations for Implementation.

1. Recommend that all services adopt the 'WGL Software for Preparing DD1547s' in order to improve the completeness and accuracy of the profit reporting system.
2. Recommend that the 'Z' score calculation be incorporated into the 'WGL Software for Preparing DD1547s'.
3. Recommend the profit 'Z'score replace the markup rate on line 35 of the Record of Weighted Guidelines Application (DD1547).

### Recommendations for Further Study.

1. Recommend recomputing 'Z' scores for both objective profit and negotiated profit using the FY90 database.
2. Recommend using the 'Z' score process control chart to investigate the reasons for the difference between the mean of the 'Theoretical Process' and the mean of the 'Actual Process'.

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Vita

Captain Gerard R Cavallo was born on 11 January, 1957 in Westwood, New  
[REDACTED]. Following graduation from Westwood High School in 1975 and he  
enlisted in the Air Force and served two years as an aircraft  
maintenance technician at Moody AFB Georgia. He received an appointment  
to the U.S. Air Force Academy in 1977 and graduated in 1981 with a  
Bachelor of Science in Engineering Mechanics. Upon graduation, he  
received a regular commission in the USAF and served his first tour of  
duty at Hanscom AFB Massachusetts. As a test manager for the Airborne  
Warning and Control system program office he planned, organized and  
directed both aircraft and simulator test programs. In 1985 he was  
reassigned to the Defense Contract Administration Service New York  
Region where he served as a warranted administrative contracting officer  
until entering the School of Systems and Logistics, Air Force Institute  
of Technology, in May 1989.

[REDACTED] :

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[REDACTED]

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204 Arlington, VA 22202-4302 and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE

September 1990

3. REPORT TYPE AND DATES COVERED

Master's Thesis

4. TITLE AND SUBTITLE

THE NET IMPACT OF "OTHER VARIABLES" ON  
NEGOTIATED PROFIT FOR DEPARTMENT OF DEFENSE  
CONTRACTS

5. FUNDING NUMBERS

6. AUTHOR(S)

Gerard R. Cavallo, Captain, USAF

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Institute of Technology, WPAFB OH 45433-6583

8. PERFORMING ORGANIZATION  
REPORT NUMBER

AFIT/GSM/LSP/90S-4

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING / MONITORING  
AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT

Approved for Public Release; Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The objective of this thesis was to determine if profits negotiated on DOD contracts were a direct result of the Weighted Guidelines Profit Analysis Method, or if 'Other Variables' had a net impact. The thesis proposes a model for the Defense Profit Process then focuses on the portion of the model which describes the steps from weighted guidelines to negotiated profit. Two paths are proposed between weighted guidelines and negotiated profit, the 'Actual Process' which includes the 'Other Variables' and the 'Theoretical Process' which does not. The results of both processes are measured using the profit 'Z' score. The profit 'Z' score is the number of standard deviations that separate the negotiated profit from the mean of the distribution of all possible profits. The analysis concludes that the average 'Z' score for the 'Theoretical Process' does not equal the average 'Z' score for the 'Actual Process', therefore the 'Other Variables' do have a net impact on negotiated profits. It is proposed that the profit 'Z' score replace the mark-up rate as a measure of negotiated profit. The profit 'Z' score provides a better measure of compliance with profit policy and is useful for individual feedback and process control.

14. SUBJECT TERMS

Profit, Cost Analysis, Contract Proposals  
Contract Administration

15. NUMBER OF PAGES

110

16. PRICE CODE

17. SECURITY CLASSIFICATION  
OF REPORT

Unclassified

18. SECURITY CLASSIFICATION  
OF THIS PAGE

Unclassified

19. SECURITY CLASSIFICATION  
OF ABSTRACT

Unclassified

20. LIMITATION OF ABSTRACT

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